



## ATTACHMENT 12

Superfund Record of Decision:  
Martin Marietta, Denver Aerospace, CO  
(EPA/ROD/R08-90/035)  
September 1990



**EPA**

## **Superfund Record of Decision:**

PB91-921483

**Martin Marietta, Denver  
Aerospace, CO**

REPRODUCED BY  
U.S. DEPARTMENT OF COMMERCE  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
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15. Supplementary Notes							
16. Abstract (Limit: 200 words)  The 5,200-acre Martin Marietta, Denver Aerospace site is in Waterton, Jefferson County, Colorado. The site completely surrounds 464 acres of contaminated Air Force property, which is being addressed as a separate Superfund site. Since 1950, the Martin Marietta Aeronautics Group (MMAG) has been conducting high technology engineering, design, development, and manufacturing operations for the space industry onsite. Types of wastes generated during onsite activities include oils, metals, organic solvents, wastewater, chemical process sludges, and VOCs. From 1959 to 1980, untreated, highly concentrated waste from onsite activities was disposed of in five onsite ponds, referred to as the Inactive Site Ponds Area. An estimated 2,100 cubic yards of waste and 24,000 cubic yards of contaminated soil are contained in the Inactive Site Ponds Area. From 1957 to 1969, solid wastes and construction debris generated at the site were disposed of in an 11-acre landfill known as the Rifle Range Landfill. In addition, waste was stored in underground storage tanks in an area referred to as the Chemical Storage Area. Previous site remediations by MMAG from 1969 to 1985 did not address contaminant sources or migration, but included backfilling and regrading of the Rifle Range Landfill; consolidation of soil and wastes from two onsite disposal ponds into one pond  (See Attached Page)							
17. Document Analysis a. Descriptors Record of Decision - Martin Marietta, Denver Aerospace, CO First Remedial Action Contaminated Media: soil, debris, gw Key Contaminants: VOCs (TCE, toluene, xylenes), other organics (PCBs, pesticides, phenols), metals (chromium, lead)  b. Identifiers/Open-Ended Terms          c. COSATI Field/Group							
18. Availability Statement	19. Security Class (This Report) None	21. No. of Pages 162					
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Abstract (Continued)

and covering of the ponds with soil; and operation of a ground water recovery system. EPA investigations have identified the Inactive Site Ponds and the Chemical Storage areas, both located to the north of the main facility, as the two major sources of onsite soil and ground water contamination. This Record of Decision (ROD) addresses remediation of onsite contaminated soil, waste/debris, and ground water. The primary contaminants of concern affecting the soil, debris, and ground water are VOCs including TCE; toluene, and xylenes; other organics including PCBs, pesticides, and phenols; and metals including chromium and lead.

The selected remedial action for this site has been divided into three separate areas: the Inactive Site Ponds Area, the Chemical Storage Area, and the ground water in the south central portion of the site. Remediation of the Inactive Site Ponds Area includes dewatering 1.3 million gallons of water from perched water zones; excavating and incinerating offsite 2,100 cubic yards of organic waste/soil material from in and around the ponds; thermally treating onsite 24,000 cubic yards of organic-contaminated soil; solidifying and stabilizing remaining soil contaminated with inorganics; backfilling excavated areas with the treated soil, and covering the ponds area with a RCRA-multilayer cap. Remediation of the Chemical Storage Area includes treating VOC-contaminated soil using in-situ soil vapor extraction, incinerating, and disposing of offsite any residual organic-laden sludge from the thermal extraction treatment system at the ponds area along with any spent carbon from the in-situ soil vapor extraction process. Contaminated ground water remediation includes onsite pumping and treatment using air stripping, carbon adsorption, ion exchange, UV photolysis/oxidation, chemical reduction, and precipitation, followed by onsite discharge to surface water; and ground water monitoring. The present worth cost for this remedial action is \$58,240,000, which includes an annual O&M cost of \$1,231,500 for 30 years.

PERFORMANCE STANDARDS OR GOALS: Both onsite and offsite ground water will be treated to meet SDWA MCLs or MCLGs. Chemical-specific ground water cleanup standards include benzene 5 ug/l (MCL), arsenic 50 ug/l (MCL), chromium 50 ug/l (MCL), lead 5 ug/l (MCL), and TCE 5 ug/l (MCL). Chemical-specific soil cleanup levels are based on soil action levels and TCLP treatment standards including toluene 28 mg/kg (TCLP), PCB 1.0 mg/kg (TCLP), and TCE 0.09 mg/kg (TCLP).

**RECORD OF DECISION  
FOR**

**Martin Marietta Astronautics Group Site  
Waterton, Colorado**

**FINAL  
September 19, 1990**



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VIII

999 18th STREET - SUITE 500  
DENVER, COLORADO 80202-2405

Ref: 8HWM-SR

SEP 24 1990

MEMORANDUM

TO: James J. Scherer  
Regional Administrator

FROM: Robert L. Duprey, Director *R. L. Duprey*  
Hazardous Waste Management Division

SUBJECT: Recommendation to Approve the Record of Decision for  
the Martin Marietta Astronautics Group (MMAG) Site

I am recommending that you sign the attached Record of Decision (ROD) for the MMAG Site.

The selected remedy calls for the Inactive Site Ponds soils to be treated using the following steps: de-watering; excavation; off-site treatment and disposal of waste; thermal extraction of backfill and alluvium; above ground stabilization of backfill and alluvium, and cap. For the Chemical Storage Tanks in the M3 Manufacturing Area, the selected remedy calls for the soil to be treated using vapor extraction. For the ground water, site-wide, the selected remedy calls for interception and treatment using five recovery well systems across the Site. The ground water will be treated on-site to remove organic and inorganic contaminants.

The remedy will be protective of human health and the environment because it will address the principal threat, the Inactive Site area, which is a major source of ground water contamination. The remedy will restore ground water to a quality that will allow for its beneficial use as a drinking water supply.

The remedy will accomplish this level of protection by meeting the following remediation goals:

1. Waste (approximately 2,100 cubic yards) in the Inactive Site Ponds will be transported to an off-site facility for treatment and disposal as Resource Conservation and Recovery Act (RCRA) hazardous waste.

2. Contaminated soil (approximately 24,400 cubic yards) will be treated by removing organic contaminants and stabilizing inorganics to prevent future impacts to ground water quality and minimize the potential for contact with contaminants in the soil.
3. Ground water will be treated to meet drinking water standards both on and off Site. (Restoration may take as long as 45 years before alluvial ground water meets drinking water standards on Site.)

Two sets of comments were received on the preferred alternative. The National Toxics Campaign recommended emission controls for the on-site air stripper and was interested in overseeing the work as a third party. MMAG requested flexibility in implementing any decision made and expressed the concern that the Environmental Protection Agency was being overly restrictive on cleanup levels by projecting residential use in the future. MMAG recommended another alternative be left in the ROD to supplement the selected remedy. These comments have been addressed in the responsiveness summary and in the ROD itself.

The State has concurred with the remedy and has been requested to jointly sign the ROD because the Colorado Department of Health will be overseeing the remedy implementation under RCRA Corrective Action authority.

Attachment

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**Martin Marietta Astronautics Group Site  
Declaration for the Record of Decision**

**SITE NAME AND LOCATION**

Martin Marietta Astronautics Group  
Waterton, Colorado

**STATEMENT OF BASIS AND PURPOSE**

This decision document presents the selected remedial action for the Martin Marietta Astronautics Group (MMAG) site in Waterton, Colorado. The remedy includes remediation of contaminated soil in and around the Inactive Site Ponds and the Chemical Storage Tank area to the north of the main manufacturing building. Additionally, the remedy includes remediation of contaminated ground water in the south central portion of the Site (including the M3 area, branches of Brush Creek, Dry Gulch, and Filter Gulch). This remedy was developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The decision is based upon the Administrative Record for this site.

The State of Colorado concurs with the selected remedy.

**ASSESSMENT OF THE SITE**

The actual or threatened releases of hazardous substances and hazardous constituents from the site, if not addressed by implementing the response action selected in this record of decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

**DESCRIPTION OF THE SELECTED REMEDY**

The selected remedy for the Martin Marietta Astronautics Group site addresses the Inactive Site Ponds, the Chemical Storage Tank area and ground water in the south central portion of the Site. The objective of the remedy is to mitigate continued release of hazardous substances to the ground water and to prevent further degradation of the aquifer both on-site and off-site. The remedy will also prevent contaminant loading in the South Platte River which supports both domestic and recreational uses. Additionally by removing the majority of the contamination from the Inactive Site

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Ponds, the remedy will minimize the potential for future human exposure to contaminants on or off-site. The major components of the remedy include:

#### Inactive Site Ponds

- Dewatering the perched zones and contaminated alluvium and treating the water on-site (approximately 1 million gallons).
- Excavating waste and contaminated soil in and around the ponds for treatment. Approximately 2,100 cubic yards of waste will be treated and disposed of off-site in accordance with the Land Disposal Restrictions (LDRs).
- Treating contaminated soil (approximately 24,400 cubic yards) on-site using thermal extraction for organic chemicals and solidification/stabilization for inorganic chemicals. Soil which is contaminated with RCRA listed hazardous wastes will be treated to meet either the LDR treatment standards or the soil and debris treatability variance standards.
- Backfilling treated soil into the area of contamination and covering with a multi-layered cap.

#### Chemical Storage Tank Area

- Using soil vapor extraction in-situ around the Chemical Storage Tanks to remove and capture halogenated organic chemicals.

#### Ground Water

- Installing additional extraction systems on-site in Dry Gulch, Filter Gulch, the Chemical Mill Sumps, Hydrostatic Test Tank area, and possibly in the East Branch of Brush Creek (north of the Inactive Site).
- Treating the recovered ground water for volatile organic compounds (VOCs) and inorganic contaminants including heavy metals. Additionally, a process for treating N-nitrosodimethylamine (NDMA) will be installed.
- Treating the water to meet parameters established in the Colorado Pollutant Discharge Elimination System (COPDES) permit for the MMAG facility. Clean-up targets for the ground water are based on federal and state drinking water standards.

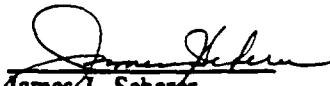
Implementation of this remedy is expected to take 4 to 5 years for the Inactive Site Ponds.

Approximately 45 years may be needed to remove contaminants in the ground water in order to meet the remediation goals.


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Statutory Determinations

The selected remedy is protective of human health and the environment, complies with Federal and State requirements legally applicable or relevant and appropriate to the remedial action, and is cost-effective. The remedy uses permanent solutions and alternative treatment technologies to the maximum extent practicable and satisfies the statutory preference for remedies that employ treatments that reduce toxicity, mobility or volume as a principal element. Because this remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a review will be conducted no less often than every five years after remediation is initiated to ensure the remedy continues to provide protection of human health and the environment.

  
James J. Scherer  
Regional Administrator  
EPA Region VIII

Sept. 24, 1990  
Date

  
Thomas P. Looby  
Assistant Director  
Office of Health and Environmental Protection  
Colorado Department of Health

Sept. 24, 1990  
Date

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**Martin Marietta Astronautics Group Site  
Decision Summary of the Record of Decision**

**1.0 SITE NAME, LOCATION, AND DESCRIPTION**

This record of decision (ROD) describes the remedial cleanup of the Martin Marietta Astronautics Group (MMAG) site.

The site is located in Jefferson County near the mouth of Waterton Canyon approximately 25 miles southwest of Denver (see Figure 1-1). The site occupies approximately 5,200 acres, and completely surrounds 464 acres of U.S. Air Force property (PJKS). The site is the location of MMAG high technology engineering, design, development, and manufacturing operations primarily for the space industry. MMAG has produced the Titan 34D7 space launch vehicle, the MX emitter, and various space shuttle subsystems at the site.

**1.1 PHYSIOGRAPHY AND MAJOR SITE FEATURES**

The west side of the site is located in the foothills of the Rocky Mountains with elevations ranging from 5,800 to 8,000 feet above mean sea level. The east side of the site is divided by the Dakota Hogback into a central valley between the hogback and the foothills and the plains east of the hogback. The elevation of the eastern areas ranges from 5,500 to 6,000 feet above mean sea level. The site has been subdivided into four major study areas. The first area contains plains stretching from the eastern boundary of the site to the Dakota Hogback. The second and third areas lie between the Dakota Hogback and the foothills. The North Central Valley area is north of the Lariat Gulch/Brush Creek divide, while the South Central Valley area is south of the divide. The Precambrian Bedrock area spreads from the western edge of the central valley to the western boundary of the site.

A majority of the development on the site is confined to the South Central Valley. The site is further subdivided into nine separate areas (Figure 1-2). These areas include:

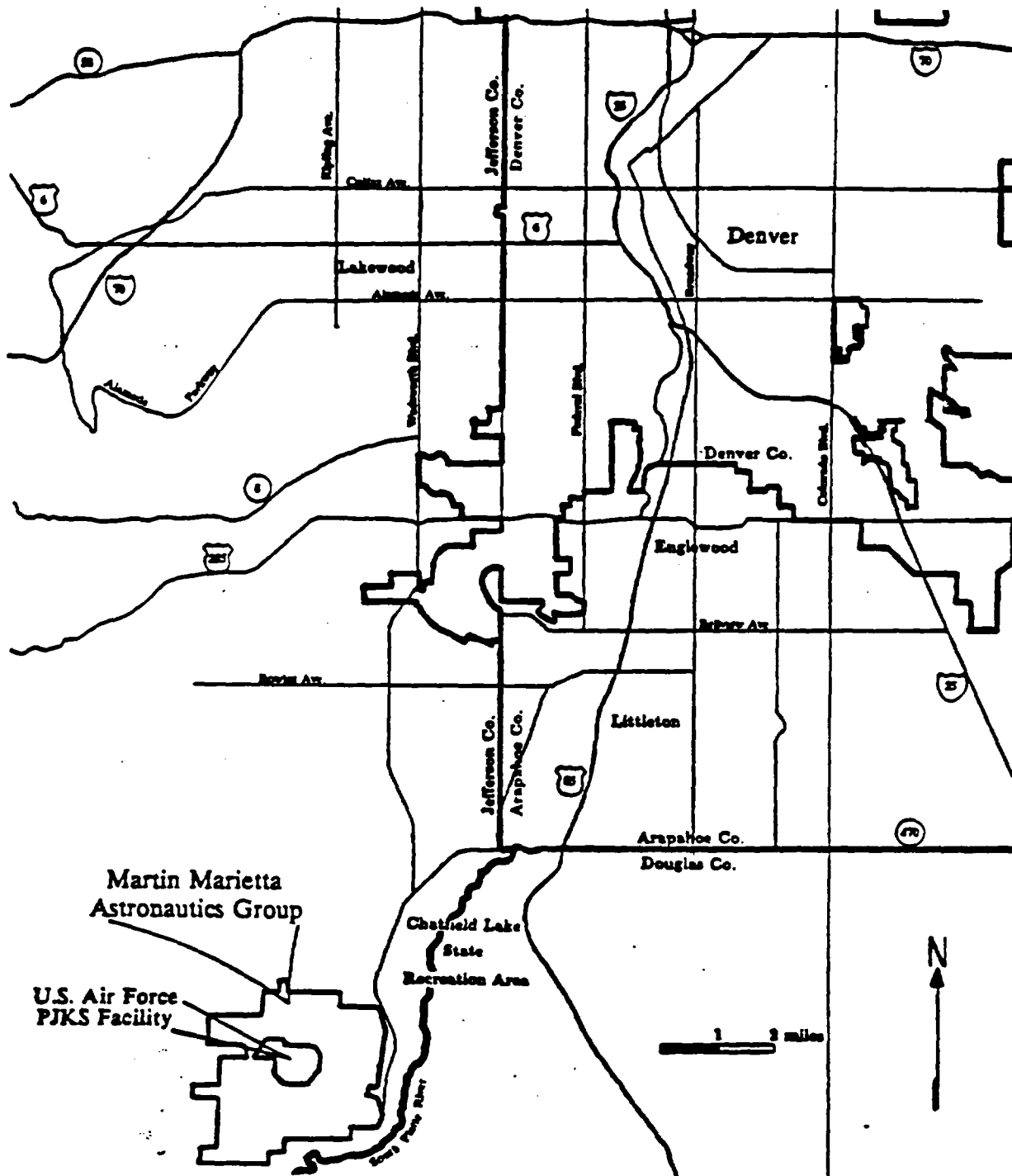
**Kassler Area**

**Filter Gulch Area**

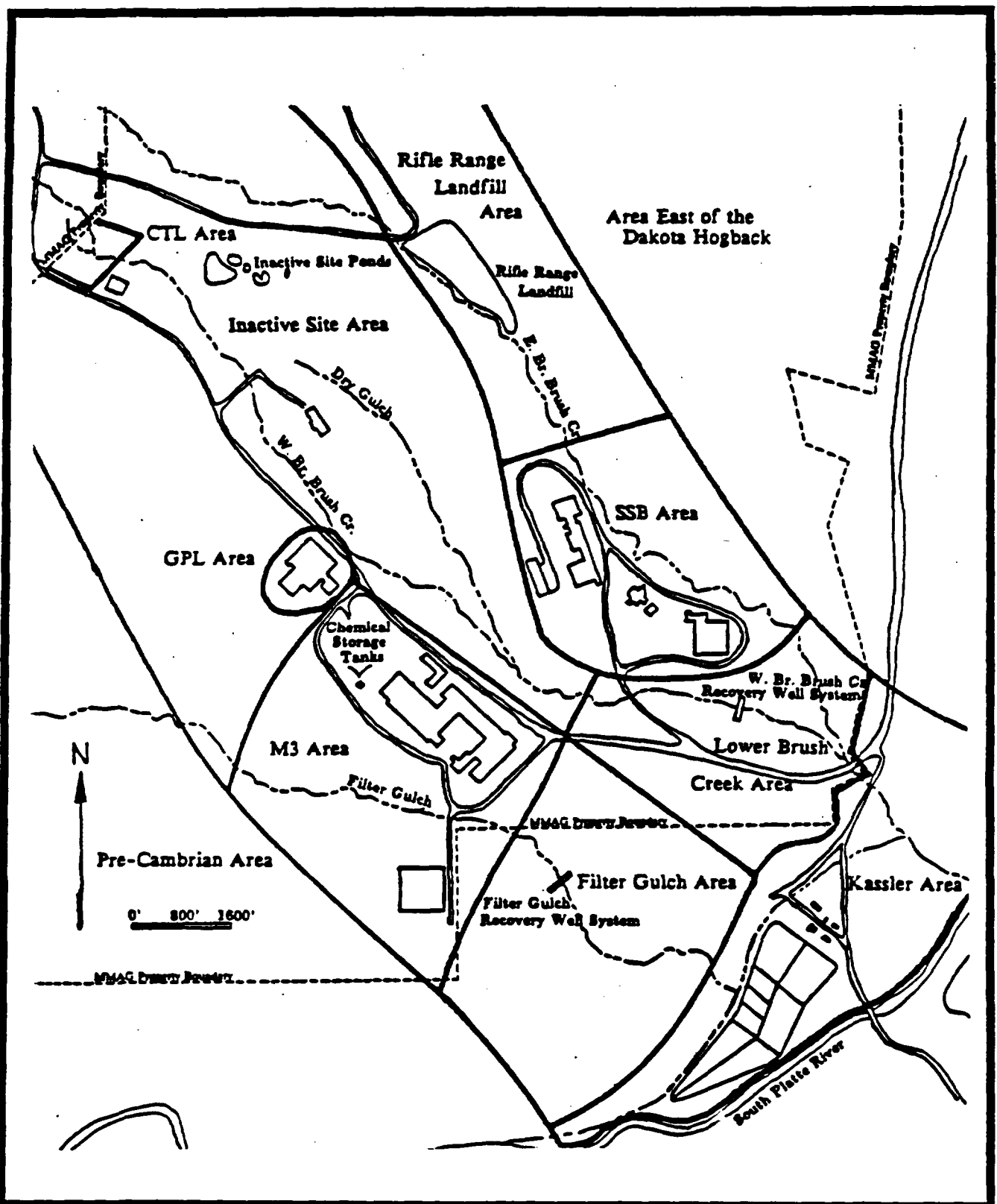
**Lower Brush Creek Area**

**M3 Area**

**Space Support Building (SSB) Area**



**FIGURE 1-1 - LOCATION OF MARTIN MARIETTA ASTRONAUTICS GROUP SITE**



**FIGURE 1-2 - MARTIN MARIETTA ASTRONAUTICS GROUP SITE**

**General Purpose Laboratory (GPL) Area**

**Chemical Technology Laboratory (CTL) Area**

**Inactive Site Area**

**Rifle Range Landfill Area**

Most of the buildings constructed at the MMAG site are located in the M3 area and SSB area. Other isolated laboratory facilities are located throughout the South Central Valley. Wastes have been managed in a few areas at the site including the Industrial Wastewater Treatment Plant (IWTP) located in the M3 area, five disposal ponds located in the Inactive Site area, and the Rifle Range Landfill located in the Rifle Range Landfill area and the Evaporation Pond in the M3 area which is a Resource Conservation and Recovery Act (RCRA) unit.

There are five major drainages of concern at the site. Lariat Gulch drains the North Central Valley area. The East and West Branches of Brush Creek drain the north and east sides of the South Central Valley area, while Filter Gulch drains the southwest corner. Dry Gulch drains a small area between the East and West Branches of Brush Creek.

Ground-water recovery systems have been constructed on the lower reaches of both the West Branch of Brush Creek and Filter Gulch. The recovery systems are designed to capture contaminated ground water moving through the stream bed alluvium. The contaminated ground water is piped to a treatment system and eventually discharged to Brush Creek below the recovery system.

## **1.2 SURROUNDING LAND USE**

The most important surrounding land use is the Denver Water Department (DWD) Kassler Water Treatment Plant (Kassler) which borders the south side of the MMAG site. Currently, Kassler is not operating. Formerly, Kassler plant collected surface water from the South Platte River and ground water from the South Platte alluvium. The surface water was obtained from an intake structure located approximately two miles upstream of the MMAG facility. The surface water was piped to the Platte Canyon Reservoir for the settling of particulates prior to filtration in the concrete-lined filter beds located adjacent to the river. Following filtration, the water was chlorinated and then transferred to an underground storage tank. Surface water was occasionally diverted to the Platte Canyon Reservoir via the Highline Canal and Last Chance Ditch.

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Ground water was collected using a series of infiltration galleries constructed in the saturated alluvium along the South Platte River. Ground water was withdrawn from the infiltration galleries after collecting at the 5-sided well. The water was chlorinated and then blended with surface water in the underground storage tank. The 5-sided well was shut down in December 1984 following the detection of low levels of TCE in the South Platte alluvium. Last Chance Ditch may also have been impacted by contaminated water coming from seeps in the Filter Gulch area. In December 1985, all water treatment operations were discontinued at the Kassler plant. The plant is maintained so that it may be brought back on-line in the future.

The Chatfield Reservoir State Recreation area is located northeast of the MMAG site. Chatfield Reservoir is extensively used for boating, hiking, and many other recreational activities. The area outside the recreational area is zoned A-1 and A-2, meaning that development plots must be at least 10 acres. There are scattered residences throughout this area.

Two miles north/northeast of the site is the planned development, Chatfield Green Activity Center. It will cover 346 acres and contain office, research, and industrial facilities as well as 600 dwelling units. Two miles northwest of the site is the Red Mesa Quarry. The area has been zoned for industrial use only. To the west, the land is zoned A-1 restricting development plots to greater than 35 acres. Only scattered residences exist in this area.

An inventory of ground water wells in the area surrounding the site shows that there are currently no wells with a domestic-use permit. Previously, five domestic-use wells were permitted in the immediate vicinity. Four wells permitted to the DWD in 1954 and 1956 were abandoned in 1971. A fifth well permitted in 1956 no longer exists.

Water in the South Platte River is used as a source for drinking water by the city of Englewood. The water intake is 3 miles south of Chatfield Reservoir.

### 1.3 METEOROLOGY

The weather at the site is typical for the east flank of the front range of the Colorado Rocky Mountains. It is temperate with average high temperatures of 70 degrees (°) Fahrenheit (F) in July and 29°F in January. It is semi-arid with an average of 17.75 inches of rainfall per year. Atmospheric pressure is approximately 83 percent of that at sea level because of the elevation. Humidity averages 50 percent and the mean average evaporation is between 50 inches and 60 inches per year. Eighty percent of the precipitation falls between April 1 and September 30. Snow is

possible year round, but the heaviest snow falls are in March. Prevailing winds are from the south and southwest at 9 miles per hour, with the strongest winds in March and April.

#### 1.4 GEOLOGY

The oldest rock type occurring at the MMAG site is Precambrian age granite and metamorphic rocks. These rocks make up the mountainous terrain on the west side of the site. The Pennsylvanian age Fountain Formation nonconformably overlies the igneous and metamorphic rocks. The Fountain Formation is 2,200 feet thick and outcrops or subcrops below most of the Inactive Site area, M3 area, GPL area, and Filter Gulch area. The Fountain Formation and the overlying sediments units have been tectonically uplifted and now strike to the northwest and dip to the northeast.

The Fountain Formation consists primarily of laterally discontinuous layers of poorly sorted conglomeratic sandstone, sandstone, and sandy and silty claystone.

The Permian age Lyons Sandstone conformably overlies the Fountain Formation. The Lyons Sandstone is approximately 235 feet thick and consists primarily of fine-to-coarse-grained quartz sandstone. It is moderately resistant and forms a small hogback through the South Central Valley area.

The Permian to Triassic age Lykins Formation conformably overlies the Lyons Sandstone. The Lykins Formation includes three members: Bergen/Harriman Shale, Glennon Limestone, and Strain Shale. The basal 112 feet thick Bergen/Harriman Shale consists primarily of reddish-brown silty shale. The 15-foot thick Glennon Limestone is a pink and gray, thinly laminated limestone with locally well developed secondary porosity. The 250-foot thick Strain Shale consists primarily of yellow-brown shale.

The Jurassic age Ralston Creek Formation disconformably overlies the Lykins Formation. The Ralston Creek Formation is 50 feet thick and consists of interbedded, fine-grained sandstone, limestone, and shale. The Ralston Creek Formation is overlain by the Jurassic age Morrison Formation. The Morrison Formation is approximately 360 feet thick and consists primarily of multicolored shale with thin, interbedded sandstones and limestones. The Lykins, Ralston Creek, and Morrison Formations are all non-resistant valley forming formations.

The Cretaceous age Dakota Group unconformably overlies the Morrison Formation. The 320-foot thick Dakota Group includes the South Platte and Lyle Formations. Both formations

consist primarily of massive, crossbedded sandstone with conglomeratic zones interbedded with lesser amounts of shale, siltstone, and claystone. The Dakota Group is very resistant and forms the prominent hogback which separates the Central Valley area from the area east of the Dakota Hogback.

The Dakota Group is overlain by the Cretaceous age Graneros Shale, Greenborn Limestone, Carlisle Shale, Niobrara Formation, and Pierre Shale. These formations consist primarily of shale with thin limestone beds and cumulatively are more than 6,300 feet thick. They are non-resistant and form the plains extending east of the Dakota Hogback.

The youngest geologic materials at the site include unconsolidated soil and alluvium. The soils are loams containing differing amounts of clay, sand, and gravel. They tend to be well drained and have moderate to low permeability. The alluvium is thickest in the stream drainage and is only a thin veneer or is completely absent over the topographic high. In the Central Valley area, the alluvium reaches a maximum thickness of 35 feet and consists primarily of silts or clayey sand with local accumulations of clay, silt, gravel and boulders. In the Kassler area, the alluvium may reach a thickness of 50 feet and is dominated by gravel and boulders.

## 1.5 HYDROLOGY

There are two major components to the MMAG site hydrologic system: alluvial ground water and bedrock ground water. The interconnection between the two systems has not been completely defined. The alluvial ground water occurs in narrow bands of alluvium along the major stream drainage of Filter Gulch, the East and West Branches of Brush Creek, Dry Gulch, and the South Platte River. The alluvium is generally thin throughout the MMAG site but reaches a thickness of approximately 50 feet along the South Platte River.

The alluvial aquifer is recharged by rainfall, surface water, and discharge from the bedrock aquifer. The alluvial ground water tends to flow downgradient, parallel to the stream drain, eventually discharging to the South Platte River alluvium. The alluvial ground water may also discharge to seeps, directly to surface water, or to the underlying bedrock. The hydraulic conductivity of the alluvial aquifer varies from 0.032 feet per day to 212 feet per day throughout the MMAG site.

Ground water also occurs in the bedrock formations underlying the MMAG site. Bedrock ground water flow is best characterized in the Fountain Formation underlying the Central Valley area. Water table, semi-confined, and confined conditions exist in different areas and at different

depths in the Fountain Formation. Recharge may be from direct infiltration of precipitation or from discharge from the alluvial aquifer. Ground water flow paths are variable due to lithologic inhomogeneities but, in general, flow is greatest parallel to strike and down dip. Overall, the ground water flow gradient in the Fountain Formation is southeast toward the South Platte River. On average, the hydraulic conductivity is an order of magnitude less than in the alluvial aquifer.

Bedrock ground water flow is not as well understood as in other bedrock formations; however, some characterization has been completed. Characterization of the hydrologic properties of the Precambrian age igneous and metamorphic rocks indicate that ground water flow is dominated by fracture flow and is under artesian conditions in most areas. In addition, the development of secondary porosity has been observed in the Glennon Limestone and Morrison Formation which results in ground water flow rates similar to the rates observed in the alluvial aquifer. Finally, the thick, Cretaceous age, shale dominated formations east of the Dakota Hogback are believed to form a hydrologic confining layer preventing ground water migration to the important aquifer formations in the Denver Basin.

The surface flow in the major drainage has been measured using a flume at regular intervals along all the creeks. The branches of Brush Creek have a combined flow rate ranging from 0 gallons per minute (gpm) to 80 gpm in the upper reaches. In the lower reaches, Brush Creek's flowrate gains considerably due to effluent discharge from the MMAG wastewater treatment plant. At its mouth in the Kassler area, it has a flow rate of 300 gpm to 1,000 gpm. Both Filter Gulch and Lariat Gulch have flow rates ranging from 0 gpm to 20 gpm. The South Platte River has flow rates ranging from 0.1 cubic feet per second (cfs) to 5,700 cfs. The DWD is required to maintain a flow rate of 30 cfs. The infiltration galleries at Kassler allow surface water to be diverted into the South Platte alluvium near the 5-sided well.

## **2.0 SITE HISTORY**

MMAG purchased the site in the mid-1950s and subsequently built the manufacturing facilities in what is known as the M3 area. In the mid-1960s, the space park facilities were built in the Space Support Building (SSB) area. Isolated laboratories have been built at the site periodically since the 1960s.

### **2.1 WASTE GENERATION AND DISPOSAL**

The main waste types generated by on-site activities are various oils, fluoride, aluminum, chromium, titanium, nitrate, cyanide, organic solvents, acid etching sludges, chemical treatment



sludges, and propellants. From 1959 to September 1980, all the waste that could not be treated on-site was disposed of in the five Inactive Site Ponds. Two of the ponds were used on a regular basis, while the other three were used sporadically. The ponds cover approximately 4.1 acres. Ponds 1 and 4 may have had clay liners at one time. However, site investigations indicate that no pond is completely lined with clay.

The one on-site landfill, Rifle Range Landfill, was active from 1957 to 1969. From 1957 to the early 1960s, it was used as a source for sand and gravel. From the early 1960s to 1968, it was used for the disposal of refuse, construction debris, and other solid wastes generated on-site. In 1969, it was backfilled and regraded. It covers approximately 11 acres, is 1,200 feet long and between 100 feet and 500 feet wide.

MMAG built a wastewater treatment plant in the M3 area during initial development. The wastewater treatment plant was designed to handle the septic and industrial waste generated on-site. The current treatment process includes chemical treatment, precipitation, filtration, and sludge separation. Industrial waste is stored in tanks and sumps before transportation to the wastewater treatment plant. Ground water from the extraction well systems is also piped to the treatment plant and stored in a tank prior to treatment. All the wastewater is stored in a tank after treatment during chemical analysis to determine compliance with standards of the discharge permit. The effluent is finally discharged to Brush Creek under permit number COPDES #CO-001511.

The current container storage area has been in operation since RCRA requirements went in effect in 1981. All waste that cannot be treated on-site is containerized and shipped to the container storage facility. MMAG is presently seeking a RCRA operating permit.

## 2.2 ENFORCEMENT HISTORY

On November 17, 1980, pursuant to section 3005 of RCRA, MMAG filed a RCRA Part A application for the treatment, storage, and disposal of hazardous waste at the facility. Revised Part A applications were submitted in 1985, and a Part B was submitted in November 1985. In August 1990, MMAG submitted a revised Part B application which is under review at the Colorado Department of Health (CDH).

On February 27 and March 14, 1985, CDH and EPA, respectively, issued Administrative Orders requiring MMAG to address contaminant releases that were detected in the Kassler area southeast of the MMAG property. The MMAG site was proposed for listing on the National Priorities List (NPL) on September 5, 1985 based upon the findings of a site inspection and evaluation

of the site risks using the hazard ranking system. On February 7, 1986, EPA and MMAG signed the Administrative Order on Consent pursuant to section 106(a) of CERCLA and section 3008(h) of RCRA. Under this agreement, MMAG conducted a remedial investigation and feasibility study (RI/FS) in accordance with provisions of the NCP. The remedy is being selected under the NCP and CERCLA. However, EPA anticipates this remedy will be implemented under the RCRA authority.

Hazardous waste management units at the MMAG facility are undergoing closure in compliance with an Administrative Order with CDH. CDH was authorized to implement the RCRA program in 1984 and is responsible for regulating the MMAG facility.

The Hazardous and Solid Waste Amendments (HSWA) of 1984 expanded the scope of the RCRA program to include provisions that allow EPA to require corrective action when there is a release of hazardous waste or constituents from any solid waste management unit at an interim status or permitted facility. CDH now has the authority to require corrective action at facilities operating under interim status or a permit, including the MMAG Facility. It is EPA policy to defer placing sites on the NPL that can be addressed by RCRA corrective action authorities. Since the MMAG facility satisfies this policy, EPA has dropped the MMAG site from the proposed NPL. Because the remedy selected in this ROD is consistent with both CERCLA and RCRA, the remedy will be implemented using the corrective action authority under RCRA.

MMAG operates a wastewater treatment plant for which CDH has issued a COPDES permit. Additionally, the facility has an air emissions permit from CDH.

## 2.3 PREVIOUS STUDIES

In 1961, MMAG began sampling selected monitoring wells for inorganic contamination. In 1981 in compliance with RCRA regulations, ground water monitoring of all RCRA and non-RCRA facilities began. In February 1986, large scale site investigations began. A complete listing of all the reports generated can be found in Tables 2, 3, and 4 of the RI report (Geraghty & Miller, 1990a). A brief description of the activities and results of each report can be found on pages 6 through 19 of the final RI report. The RI was finalized in March 1990 and the FS was finalized in June 1990.

## **2.4 REMEDIAL ACTIVITIES**

Besides the cleanup of some small spills and RCRA unit closures, there have been four remediation efforts undertaken at the site. The first was the backfilling and regrading of the Rifle Range Landfill in 1969. This effort did not address any of the contaminant sources or the migration of contaminants. The second remediation effort occurred when the contents of Pond 2 were bulldozed into Pond 1 and all the ponds were covered with soil fill in 1980. This effort did little to contain contaminant sources or to prevent contaminant migration. The third effort became necessary when contamination in the ground water was detected off-site. In September 1985, MMAG began operation of a ground water recovery system across Filter Gulch. Between 6,500 gallons and 10,000 gallons of contaminated ground water are recovered each day and sent to the wastewater treatment plant. In April 1987, MMAG began operation of the West Branch of Brush Creek recovery well system. The 3 24-inch recovery wells in a gravel backfilled trench recover between 18,000 gallons and 28,000 gallons of contaminated water per day. The water is piped to the MMAG Industrial Wastewater Treatment Plant (IWTP) for treatment.

## **2.5 U.S. AIR FORCE (PJKS) PROPERTY**

The U.S. Air Force owns approximately 464 acres within the MMAG property. It is an NPL site, and it is being addressed separately from the MMAG site.

Portions of an RI/FS have been conducted by the Air Force, and an Interagency Agreement is being negotiated with EPA, CDH and the Air Force to complete work at the site.

Contamination from the Air Force property has migrated onto MMAG property. There are two locations, upper reaches of Brush Creek and Lariat Gulch, where contaminants emanate from Air Force property. EPA anticipates that source controls will be addressed by the Air Force, but ground water may be addressed by both MMAG and the Air Force.

## **3.0 COMMUNITY PARTICIPATION**

Community relations activities for the MMAG site began in February 1986 when EPA interviewed local officials, area residents, various group representatives, CDH personnel, and other EPA personnel. The individuals represented a cross-section of diverse interests, including state and local government, environmental groups, peace and anti-nuclear groups, homeowner groups, and area business and civic groups.

The interviews were based on questions recommended for on-site discussion as outlined in the "Interim Community Relations in Superfund Handbook," dated 1983. The interviews were conducted informally and interviewees were encouraged to expand on comments according to their interests. EPA also maintained regular contact with interested groups and individuals, congressional offices, the governor's office of Colorado, and the mayor's office of Denver.

On March 24, 1986, EPA held a public meeting at Columbine High School to explain the Superfund process and the Administrative Consent Order issued by EPA in February 1986 to Martin Marietta.

On March 24, 1986, EPA also produced an initial fact sheet. This fact sheet provided background information on the MMAG site, information on studies to occur at the site, and community relations information. The fact sheet also requested comments on the RI/FS work plan and address information.

On May 29, 1986, interested groups, members of Governor Richard Lamm's staff, EPA, CDH, and MMAG officials met to discuss the possible formation of a governor's monitoring committee for the MMAG site. It was decided that a monitoring committee was not necessary. However, it was agreed that to maintain community involvement, EPA would produce a series of information updates and schedule quarterly public meetings.

As a result, EPA produced eleven information updates from June 1986 through November 1989; scheduled quarterly public meetings as agreed to by Governor Richard Lamm, interested citizens, EPA, and CDH; and held a site tour on June 8, 1986. EPA held the first quarterly public meeting for the site on July 17, 1986.

In June 1986, EPA finalized the community relations plan (CRP). EPA based the CRP on information gathered through interviews and meetings. The resulting CRP outlined citizen concerns and identified the methods by which EPA would keep citizens informed and involved in decisions about studies at the site.

On September 11, 1986, EPA attended a meeting of the Deer Creek Mesa Homeowner's Association to discuss the area geology, hydrology, and the studies at the site in relation to homeowner wells. EPA subsequently sampled 10 wells in the area to determine if contamination had reached any potable wells in the Deer Creek Mesa area.

EPA also compiled and maintained a mailing list of approximately 300 names and addresses. Announcements and updates were regularly sent to this mailing list. Public meetings were regularly announced in the information updates and in local newspapers. EPA also produced a number of press releases during the early stages of activity at the site announcing the Administrative Order on Consent, site activities, and public meetings.

By September 1987, EPA had held five public meetings. Less than 10 community members attended the last three meetings. Due to this low attendance, EPA issued a letter on August 24, 1987 to everyone on the mailing list stating that unless there was significant community opposition, EPA would discontinue the quarterly public meetings. Only one letter was received opposing discontinuation of these meetings. EPA continued holding public meetings at key points during the remaining stages of the Superfund studies at the site.

### 3.1 CHRONOLOGY OF COMMUNITY PARTICIPATION ACTIVITIES

#### RI Documents

EPA obtained public comment on the RI documents produced for the site as outlined in the CRP. Initially, MMAG submitted a draft work plan for the entire RI/FS to EPA on March 10, 1986. On March 11, 1986, EPA published a press release announcing the beginning of the public comment period on the work plan and to announce the March 24 public meeting. The public comment period was scheduled to continue through March 28, 1986.

EPA obtained public comment on this document at the public meeting held at Columbine High School. EPA also accepted public comments in writing, by mail, and over the phone. Along with the public comments received, EPA provided technical comments to MMAG on the work plan document. The work plan established that the RI would be performed in three phases and that a report would be completed and public comment received after each phase.

In June 1987, EPA announced a regular quarterly meeting. EPA also announced that public comments would be accepted on the Phase 1 report, which detailed the studies conducted since the beginning of the project. The report also incorporated the results of hydrogeologic, soils, and water quality investigations at the facility since October 1985. The meeting was held on June 23 and the public comment period ended on July 10, 1987. No public comments were received during that time period.

Once Phase 1 was completed, work began on Phase 2. Phase 2 was designed to conduct additional investigations at sites within the MMAG facility which were identified in Phase 1 as potential sources of contamination. Phase 2 identified four sites that required further study.

- 1) The Vertical Test Facility/General Purpose Lab Ditch (in the Brush Creek vicinity)
- 2) The abandoned waste lines from the Chem Mill to the IWTP
- 3) The west side of the factory acid and alkaline solution spills
- 4) The Chemical Storage Tanks between the north door of the factory and the Hydrostat Test Facility

On November 1, 1988, EPA held a public meeting to discuss the results of the Phase 2 investigations. Subsequently, Phase 3 began an effort to better determine the extent of contamination at the four locations identified in Phase 2.

### **Feasibility Study**

After completion of the three-phased RI, EPA and MMAG completed an FS describing various alternatives for site cleanup based on contaminants identified in the RI. The FS was finalized in June 1990.

The public comment period for the FS and proposed plan began June 28, 1990 and ended on August 27, 1990. A public meeting to provide information on the preferred alternative and to collect comments was held on July 26, 1990 at Deer Creek Junior High School. The proposed plan, which included an announcement of the public comment period and meeting, was sent to all individuals on the mailing list. The meeting was also announced in display ads in the Denver Post, Rocky Mountain News, and the Lakewood and Littleton Sentinels. These were also the official notices of availability of the proposed plan for review and comment. The FS and proposed plan were added to the information centers for public comment.

### **3.2 LOCATION OF INFORMATION CENTERS**

EPA identified five information centers for availability of site documents for public review. The RI/FS, proposed plan, and other related documents are available for review at these five locations. Other related documents available at the centers include the 1986 Administrative Order on Consent, public health evaluation and environmental assessment, various ground water reports, updates, the CRP, and work plans. The locations are as follows:

- Lakewood Public Library  
10200 W. 20th Avenue  
Lakewood, CO 80215
- Denver Public Library  
1357 Broadway  
Denver, CO 80203
- Colorado Department of Health  
Room 351  
4210 E. 11th Avenue  
Denver, CO 80220
- Columbine Public Library  
7706 W. Bowles Avenue  
Littleton, CO 80123
- EPA Library  
U. S. Environmental Protection Agency  
999 18th Street, Suite 215  
Denver, CO 80202-2413

The administrative record is also available for public review at the Superfund Records Center on the fifth floor of the EPA building, located at 999 18th Street in Denver, Colorado.

#### **4.0 SITE CHARACTERIZATION**

##### **4.1 SOURCES OF CONTAMINATION**

During the course of 30 years of operations at the facility, contamination of the soil and water on-site has occurred and is attributable to several sources. The objective of the RI was to identify those sources and define the nature and extent of the contamination from those sources. The scope of the RI was limited to areas not already addressed under the RCRA program implemented by the State of Colorado since 1984. Additionally, the study did not include the U.S. Air Force (PJKS) property because there is a separate RI/FS being conducted for the Air Force property which is an NPL site.

The RI was conducted in several phases and the results of each phase are described in the RI report (Geraghty & Miller, March 1990). The final RI had identified the Inactive Site Ponds as the major source of soil and ground-water contamination at the site. Additional areas of contamination that were evaluated in the last phase of the RI, Phase 2, included the Chemical Storage Tank area, Abandon Waste Line, the Vertical Test Facility/General Purpose Lab Ditch and the West Side of

Factory spills. Of these additional locations, the Chemical Storage Tank area near the north door of the factory is the only location where significant levels of contamination were found in the soil.

The Rifle Range Landfill was also investigated and the results showed no contaminant levels of concern in the landfill. There are low levels of ground water contamination below the landfill that may emanate from areas upgradient.

#### 4.2 AFFECTED MEDIA AND EVALUATION OF CONTAMINATION

The Inactive Site area, the principal threat at the site, contains highly concentrated waste from the manufacturing operations. The wastes types include waste oil, wastewater treatment and chemical processes sludges containing fluoride, aluminum, chromium, titanium, nitrate and cyanide, and halogenated solvents. These sludges include wastes classified as F001, F002, F005 and F019 RCRA listed waste. There are five ponds that were originally used for waste disposal. Contamination has since migrated into the soil and bedrock surrounding the ponds. An estimated 2,100 cubic yards (cy) of waste and 24,000 cy of contaminated soils are contained in the area. Because the ground water intersects portions of the Inactive Site area and infiltration has carried contaminants into the ground water, extensive ground water contamination has also resulted.

Bedrock and alluvium have been highly contaminated by chemicals leaching from the ponds. Below Pond 1, waste has infiltrated directly into the bedrock in the northeastern edge of the pond and contaminated saturated and unsaturated alluvium under the south central area of the pond. Concentrations in the alluvial ground water are approximately an order of magnitude higher than in perched water found in the Inactive Site pond area. This indicates that contaminant levels are likely higher in the alluvium than in the ponds.

The soil contamination below Pond 1 (alluvium) is not uniform according to the soil core samples. This suggests that there is a discrete nonaqueous phase liquid (DNAPL) phase present. Mackay and others (Mackey, 1985) maintain that due to diffusional limitations and dilution by dispersion, the water in contact with organic liquid phases generally has contaminant concentration levels that rarely exceed 10 percent of the saturation limit. The ground water in the alluvium below Pond 1 has TCE in concentrations exceeding 19 percent of TCE saturation limit. If the direction of alluvial ground water flow follows the slope of the bedrock surface, the alluvial ground water is moving to the south. There is the possibility that the bedrock discharges ground water to the alluvium underneath or upgradient of Pond 1. The RI determined that bedrock ground water flow is greatest parallel to strike. An examination of the water level data upgradient and parallel to the strike of the Fountain Formation indicates that the water table must dip steeply to prevent bedrock



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ground water from discharging into the alluvium. It is more likely that the water table observed in the bedrock upgradient is hydrologically connected to the water table present in the alluvium under Pond 1.

The material contained within Pond 2 was moved into Pond 1 in 1980. The core logs of the soil borings in Pond 2 indicate that there is no waste material left. Chemical analysis of samples taken from within the ponds have low levels of VOCs (less than 100 micrograms per kilogram (ug/kg)) and moderate levels of chromium (up to 464 milligrams per kilogram (mg/kg)). Pond 2 is located directly above the bedrock and there is no alluvium or alluvial ground water below the pond.

Pond 3 is also located directly above the bedrock. It contains up to 5 feet of mixed waste and clay. Detectable VOC concentration levels in the waste material range from 136 ug/kg to 9,120 ug/kg and the chromium concentration ranges from 9.6 mg/kg to 44 mg/kg. No piezometers have been installed in Pond 3; therefore the best available evidence in the core logs suggests that the waste material in the pond and the alluvium around the pond is saturated. The level of contamination in the ground water and the lateral extent of ground-water contamination are unknown.

Soil and ground water in and under Pond 4 are highly contaminated. Core samples taken from the waste material have TCE concentrations as great as 74,000 ug/kg and chromium concentrations as great as 42,500 mg/kg. The alluvium below the ponds has TCE concentrations as great as 6,500,000 ug/kg (0.65 wt%) and chromium concentrations as great as 5,360 mg/kg. More significant than this is the distribution of the TCE with depth. A concentration of 6,500,000 ug/kg of TCE was detected in a three foot core sample (SCB-28; 20 feet to 23 feet) taken from the alluvium in a low point in the bedrock. There is no discrete waste found directly above where the sample was taken. Since 6,500,000 ug/kg is substantially higher than the solubility of TCE in water (1,100,000 ug/l) and since the amount of organic carbon needed to completely adsorb the excess TCE is approximately an order of magnitude higher than expected, it is very likely that the TCE exists as a discrete phase.

Like Pond 1, there are two distinct layers of ground water in Pond 4. The upper layer occurs as perched water within the pond. Water level measurements in well GM-142 indicate that the upper layer is not permanent. It ranges in thickness from near 0 feet to over 6 feet. The lower hydrologic layer occurs in the alluvium approximately 7 feet below the upper layer. It is more than 4-feet thick. The upper layer has VOC concentrations as high as 13,200 ug/l and the lower layer has VOC concentrations as high as 596,000 ug/l. Thus, the trend in TCE concentration observed in the soil borings is mimicked by the ground water. The direction of alluvial ground water flow follows the slope of the bedrock surface; the alluvial ground water is moving to the southeast.

The levels of contamination present in and under Pond 5 are the highest measured at the site. There are only four borings within the pond area and only one of these was sampled for chemical characterization. The highest measured TCE concentration is 7,100,000 ug/kg for the waste materials and 3,300,000 ug/kg for the alluvium. Both are significantly higher than the solubility of TCE in water. Unlike Ponds 1 and 4, both the waste material and the alluvium are contained within one hydrologic layer. Pond 5 sits in a depression in the bedrock that is lined with approximately 3 feet of alluvium. The thickness of the saturated zone above the bedrock is estimated to be 7 feet and it is flowing to the southeast.

The highest observed contaminant concentrations in Ponds 1, 4, and 5 are all located at low spots in the waste mix/alluvium interface or alluvium/bedrock interface. The similar trend in all the ponds suggests that a dense phase has migrated into depressions.

A summary of the chemicals of potential concern in the Inactive Site soils and the detected concentration range is given in Table 4-1. A cross section of the ponds showing contaminant profiles is presented in Appendix B.

Contamination from the ponds has migrated with the bedrock and alluvial ground water. Contamination in the bedrock has migrated at least 800 feet down dip in the Fountain Formation. Most of the contamination detected north of the ponds can be attributed to down dip migration. Ultimately, the contamination migrating down dip will move to depths of over 6,000 feet under the Denver Basin. As described in Section 1.4, the formations which subcrop under the MMAG facility are overlain by approximately 5,000 feet of shale which should prevent contamination from moving into utilized aquifers. Contamination is also migrating along strike to the southeast. Both migration parallel to strike and recharge from the contaminated alluvial aquifer can explain the distribution of contaminants in the bedrock south of the ponds using the data on hand. It is impossible to distinguish how the contamination migrated to its present position. The bedrock shows high levels of contamination over 2,000 feet south along strike. A ridge of resistant bedrock is preventing large amounts of contamination from entering the upper reaches of the West Branch of Brush Creek. Similarly, the Lyons sandstone is preventing large amounts of contamination from entering the SSB area. The amount of contaminant migration across strike is unknown. The distribution of contamination in the Rifle Range Landfill area suggests that there is another TCE source besides the landfill. The most obvious source is the Inactive Site; however the evidence is not conclusive.

The other contaminant source area identified by the RI is the soil contamination around the Chemical Storage Tanks. The four contaminants detected in the soil at the Chemical Storage Tank area are TCE, 1,1,1-trichloroethane (TCA), 1,1-dichloroethene (DCE), and total nitrogen. The

**TABLE 4-1**  
**MARTIN MARIETTA ASTRONAUTICS GROUP SITE**  
**CONCENTRATION RANGE FOR CHEMICALS OF CONCERN**  
**INACTIVE SITE POND AREA**

Chemicals of Concern	Total Concentration Range	
	low	high
<b>VOLATILE ORGANIC COMPOUNDS, ug/kg</b>		
Acetone	113	8,480
2-Butanone	374	23,500
1,1-Dichloroethane	57	2,860
cis-1,2-Dichloroethylene	51	126,000
trans-1,2-Dichloroethylene	63	63
Ethylbenzene	35	105,000
Methylene chloride	1,260	179,000
4-Methyl-2-pentanone	244	4,750
Tetrachloroethylene	41	1,100,000
Toluene	86	607,000
1,1,1-Trichloroethane	41	163,000
Trichloroethene	43	7,100,000
m-Xylenes	68	232,000
o+p-Xylenes	108	238,000
<b>SEMI-VOLATILE ORGANIC COMPOUNDS, ug/kg</b>		
Anthracene	2,740	2,740
Benzo(a)anthracene	2,090	4,300
Benzo(a)pyrene	3,120	3,600
Benzo(ghi)perylene	3,500	3,500
Benzo(b+k)fluoranthenes	3,180	6,960
Bis(2-ethylhexyl)phthalate	2,060	9,120
Chrysene	2,160	4,730
Di-n-butylphthalate	1,710	2,980
Fluoranthene	1,880	14,700
Indeno(1,2,3-cd)pyrene	1,740	1,890
Phenanthrene	2,000	14,100
Pyrene	1,770	8,760
1,2,4-Trichlorobenzene	2,480	4,930
Phenol	nd	nd
PCB - 1242	371	79,800
PCB - 1248	1,310	12,800
PCB - 1254	177	5,600
PCB - 1260	1,060	14,400

**TABLE 4-1 (continued)**  
**MARTIN MARIETTA ASTRONAUTICS GROUP SITE**  
**CONCENTRATION RANGE FOR CHEMICALS OF CONCERN**

**INACTIVE SITE POND AREA**

Chemicals of Concern	Total Concentration Range	
	low	high
<b>INORGANIC COMPOUNDS</b>		
Aluminum, mg/kg	1,640	158,000
Antimony, mg/kg	11.5	461
Barium, mg/kg	22	1,820
Beryllium, mg/kg	1	5.5
Cadmium, ug/kg	1.6	159,000
Chromium mg/kg	2	42,500
Chromium (hexavalent), mg/kg	0.79	9.3
Copper, mg/kg	4.7	28,600
Lead, mg/kg	3	858
Mercury, ug/kg	0.07	2,400
Nickel, mg/kg	4.7	179
Silver, ug/kg	24	28,100
Fluoride, mg/kg	9.2	253
Nitrate + Nitrite, mg/kg	0.4	71
Cyanide (total), mg/kg	1	34

extent of contamination appears to be limited to a small area under and around the tanks.

Additional source areas for ground water contamination exist in the M3 area, SSB area and the Chemical Technology Lab area. These are RCRA regulated areas not investigated as part of the RI. Large amounts of TCA, TCE, DCE, acetone, chromium, and other chemicals have been released to the ground water. In the M3 area, the ground water has been severely contaminated in three areas. The most contaminated area is at the north end of the manufacturing building. Concentrations of TCA up to 2,600,000 ug/l have been detected. Other contaminants present include TCE, DCE, acetone, methylene chloride, and chromium. In this area there is no alluvial ground water, therefore, all the contamination is located in the bedrock and the bedrock ground water.

The second contaminated area is down gradient of the Evaporation Pond, where levels of TCA up to 110,000 ug/l have been detected. Other chemicals that have been detected include DCE and chromium. Both bedrock and alluvial ground water have been contaminated. The Evaporation Pond is now undergoing RCRA closure under the supervision of CDH.

The third area of contamination is directly down gradient of the Evaporation Pond near the south end of the manufacturing building. TCE has been detected at concentrations of 150,000 ug/l. TCA and DCE also occur at high levels. There is a source for contamination in this area, but some of the TCA and DCE may have migrated from the Evaporation Pond. Both alluvial and bedrock ground water are highly contaminated in this area. The ground water contamination from these three source areas is migrating down Filter Gulch towards the Kassler facility. The contaminated alluvial ground water is intercepted by the Filter Gulch recovery well system. The contaminated bedrock ground water is migrating off-site near Filter Gulch. Before the recovery well system was installed, TCE from these sources was detected in the Kassler area.

#### **4.3 MOBILITY OF CONTAMINANTS**

##### **4.3.1 Ground Water**

The migration of contaminants in the alluvial ground water is the dominant contaminant transport process active at the site. High levels of contamination have migrated into the upper reaches of Dry Gulch. Lesser amounts of contamination continue to migrate downstream into the Brush Creek drainage and along the West Branch of Brush Creek into the South Platte alluvium around the Kassler facility. The concentration of TCE in the headwaters of Dry Gulch is as high as 67,400 ug/l in well GM-11. About half way down the gulch at well GM-80, the concentration of TCE drops an order of magnitude to 5,680 ug/l. At the point where Dry Gulch intercepts the West

Branch of Brush Creek, the concentration of TCE is about 1,800 ug/l. Above the West Branch of Brush Creek recovery well system, the concentration of TCE ranges from 36 ug/l to 260 ug/l.

Below the Brush Creek ground water recovery well system, the TCE concentration in the ground water has dropped with time. Before operation of the recovery well system, GM-69 had TCE concentrations as high as 71 ug/l. After nearly 1.5 years of operation, the concentration in the ground water had dropped below the detection limit. All the other wells down gradient of the West Branch of Brush Creek recovery well system have also shown decreases in the level of TCE contamination.

NDMA and chromium are two contaminants of concern that have migration characteristics different from TCE. NDMA is very soluble in water; therefore the speed at which it will move through the system is dependent upon the ground water velocity. The behavior of chromium is made more complicated by the different solubilities of trivalent chromium ( $\text{Cr}^{+3}$ ) and hexavalent chromium ( $\text{Cr}^{+6}$ ).  $\text{Cr}^{+6}$  is much more soluble in water therefore it is much more mobile.  $\text{Cr}^{+3}$  is not very soluble, therefore it is not very mobile. Most of the chromium detected at the Inactive Site is  $\text{Cr}^{+3}$ .

Although there is contamination in the bedrock, the Cretaceous age Grancos Shale, Greenhorn Limestone, Carlisle Shale, Niobrara Formation and Pierre Shale form a layer of very low hydraulic conductivity over 6,300 feet thick. The thickness and impermeability of this sequence will prevent any contaminated ground water in the bedrock formations that subcrop under the MMAG site from impacting the utilized aquifers in the Denver Basin.

#### 4.3.2 Surface Water and Sediments

Samples have been collected for chemical analysis during the RI from the following surface water bodies:

- Brush Creek (both branches and Lower Brush Creek)
- Filter Gulch
- Last Chance Ditch
- South Platte River
- Lariat Gulch

Surface-water contamination has been directed in both branches of Brush Creek. On the East Branch of Brush Creek, the majority of the contamination appears to be limited to two reaches. The first is from the U.S. Air Force property boundary to directly upstream of the Rifle Range Landfill where TCE, cis-1,2-DCE, trans-1,2-DCE and TCA have been detected at maximum concentrations

of 57 ug/l, 5.2 ug/l, 9.7 ug/l and 5.1 ug/l, respectively. The second is located directly east of the SSB facility. TCE is the only organic contaminant found in this portion of Brush Creek with concentrations ranging from 14 ug/l to 31 ug/l (Geraghty & Miller, 1990).

Stream-flow rates and ground water flow directions indicated that both these reaches consistently exhibit gaining conditions and that contaminated ground water is discharging to the stream. In addition, the presence of these contaminants upstream of the property boundary indicate a source is also located on the U.S. Air Force property (Geraghty & Miller, 1990).

On the West Branch of Brush Creek there are three areas of surface-water contamination. Surface water quality has been impacted near the confluence of the West Branch of Brush Creek and the dry gulch that trends southeast from the Inactive Site area. Ground water migrating down the dry gulch, through alluvium overlying the Fountain Formation, surfaces at seeps approximately 50 feet above the confluence. Samples collected at the seeps exhibited cis-1,2-DCE and vinyl chloride concentrations ranging from 5.5 ug/l to 27 ug/l, and from 3.4 ug/l to 34 ug/l, respectively.

Low levels of TCE have also been detected adjacent to the Lower Brush Creek Recovery system and approximately 500 feet upstream of the property boundary. No organic contaminants have been detected at stations located downstream of the confluence on Lower Brush Creek.

Stream sediments were sampled on both the West and East Branches of Brush Creek and only toluene was detected at one location near the Inertial Guidance Lab at a concentration of 595 ug/l.

The relatively low concentrations of inorganic compounds in ground water between the Inactive Site and the upper West Branch of Brush Creek, and the evidence that Brush Creek is a losing stream along this reach suggest that previous activities at the Inactive Site have not impacted the inorganic chemical quality of the stream sediments of the West Branch of Brush Creek.

Along the East Branch of Brush Creek, bis (2-ethylhexyl) phthalate was detected (2,750 ug/l) in the stream sediments adjacent to the Rifle Range Landfill (Geraghty & Miller, 1987e). An increase in the concentrations of inorganic chemicals such as chromium (total and hexavalent), iron, lead, fluoride, total kjeldahl nitrogen (TKN), sulfate, copper, nitrate/nitrite, phosphorus, aluminum, and zinc in sediment samples collected at surface water stations adjacent to and just downstream of the Rifle Range Landfill appears to reflect an impact to stream sediment quality from the Rifle Range Landfill (Geraghty & Miller, 1990).

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Sediment samples were collected in the lower portion of the West Branch of Brush Creek and along Lower Brush Creek, and  $C_1$ - $C_{20}$  petroleum hydrocarbons (26.0 mg/l) were detected in one sample. Fluoranthene (2,390 ug/l) and pyrene (2,430 ug/l) were also detected in one sample and may reflect the impact on the creek from storm drains which divert runoff from a nearby parking lot (Geraghty & Miller, 1990).

TCE is the primary organic contaminant detected in Filter Gulch surface water. Other organic contaminants which have also been detected in Filter Gulch are:

<u>Parameter</u>	<u>Range of Concentration (ug/l)</u>
1,1,1-trichloroethane	ND-68
cis-1,2-dichloroethene	ND-116
1,1-dichloroethane	ND-273
1,1-dichloroethene	ND-7.1
bromoform	ND-5
TCE	ND-135
vinyl chloride	ND-2.7

Five sediment samples were collected in Filter Gulch. VOCs were not detected in any of the sediment samples nor were there any inorganic constituents above the established background range.

No organic compounds have been detected in samples from Last Chance Ditch during the RI. However, ground water seeps in Last Chance Ditch show low level organic contaminants.

Surface water quality samples collected from the South Platte River at the intake of DWD conduit # 20, located approximately three miles upstream of the Kassler Treatment Plant, were only found to contain the common laboratory contaminant bis (2-ethylhexyl) phthalate (24 ug/l). The reported presence of this chemical is attributable to a laboratory bias. Additional samples collected from the South Platte River at various locations in the Kassler area by MMAG, EPA and DWD during 1983 and 1985 were free of detectable organic compounds.

No organic compounds have been detected in surface water samples collected from Lariat Gulch.  $Cr^{+6}$  was detected during a March 1987 sampling round at the method detection limit (0.01 mg/l) from a sample collected approximately 5,000 feet downstream of the northern boundary of the U.S. Air Force property.

Organic compounds have been detected at a seep on the hillside approximately 300 feet north of the Propulsion Research Lab (PRL). TCE and cis-1,2-DCE were detected at concentrations of 338 ug/l and 16 ug/l, respectively. Data developed during the ongoing IRP at the U.S. Air Force



facility indicate that this seep is fed by ground water in the bedrock (Foundation Formation) and is not directly related to conditions in the saturated alluvium at the PRL (Geraghty & Miller, 1990).

#### 4.4 MODELLING OF CONTAMINANT MIGRATION

A ground-water contaminant transport model was developed for the MMAG site to predict the concentration of the major contaminants of concern at several exposure points for which a risk assessment was performed (see Section 5.0). Exposure point concentrations were predicted for as much as 100 years into the future (1989 to 2089). First, the ground water flow model was calibrated to the water levels and volumetric flow rates at the site. Output from the flow model was then used as input to a chemical transport model which predicted the migration of contaminants at the MMAG facility between bedrock, alluvium, and surface waters. As an approximation of the uncertainty associated with the model predictions, simulations were run which used "upper bound" chemical concentrations at the contaminant sources to predict maximum plausible exposure point concentrations.

The ground water flow model of the MMAG facility is based upon the U.S. Geological Survey (USGS) computer program for the simulation of three-dimensional ground water flow (Trescott and Larson, 1976). The chemical transport model was prepared by S.S. Papadopoulos & Associates (SSP&A, 1989).

Eight source areas were considered in the contaminant transport modeling: the Evaporation Pond; the Manufacturing Building and associated facilities in the M3 area; the Space Support Building area; the Inactive Site; the Rifle Range Landfill; the General Purpose Lab (GPL); the Chemical Technologies Lab (CTL); the U.S. Air Force properties upgradient of the CTL; and the U.S. Air Force properties upgradient of the MMAG facility along the East Branch of Brush Creek.

Results of the contaminant transport modelling indicated that most of the TCE observed in the alluvial and bedrock ground water and the surface streams can be explained by migration from the Inactive Site and the M3 areas at a constant rate. In Filter Gulch the TCE distribution was best matched when a constant TCE concentration of 1,200 parts per billion (ppb) was assumed at the M3 area. This is somewhat lower than the estimated average source concentration of 1,800 ppb. In Dry Gulch, West Branch of Brush Creek, and Brush Creek, the TCE distribution was almost completely explained by migration from the Inactive Site.

There was considerable debate over developing estimates of the uncertainty associated with the model results. EPA determined that developing an accurate probability distribution for exposure

point concentrations was not possible given the large number of parameters involved in the model. Instead, it was agreed that estimates would be made for the "upper bound" exposure point concentrations. These upper bound values were considered the plausible maximum aqueous concentrations at the exposure points. The upper bound concentration at a well was defined as the mean concentration plus two standard deviations.

Exposure points for which the upper bound concentrations were evaluated included ground water wells on- and off-site, surface water in Brush Creek, the South Platte and soils on-site assuming residential and industrial exposure scenarios. The results of the risk assessment describe the risk associated with these points of exposure.

#### **Evaluation of Ground Water Remedial Alternatives**

The four ground water alternatives presented in Sections 6.6 through 6.9 were evaluated using the model to determine the amount of time required for ground water restoration. The model assumed that all sources were removed or remediated. The remedial time frames for ground water restoration for each alternative are as follows:

<u>Alternative</u>	<u>Restoration Time</u>
GW-1	More than 130 years off-site/70 years on-site
GW-2	130 years on-site/more than 5 years off-site
GW-3	45 years on-site/more than 5 years off-site
GW-4	45 years on-site/more than 5 years off-site

In simulating these remedial alternatives, the calibrated model was modified so that the alluvial ground water was completely removed at these points. The water was then reinjected into the surface water model segments corresponding to the location where outflow from the treatment system enters Brush Creek.

#### **Contaminant Transport Modelling at the Chem Mill, SSB, and Evaporation Pond**

Source areas affecting ground water which were not part of the RI/FS but are currently managed under RCRA authority, were evaluated as part of a site-wide ground water remediation plan. Modelling was used to assist in the selection of appropriate systems which were added to the ground water alternatives in the FS.

Corrective action measures at the Chem Mill, SSB, and Evaporation Pond areas were evaluated using coupled ground water flow and contaminant transport models as described for the site wide model. In the Evaporation Pond area the same site wide models described previously were used to evaluate contaminant transport. At the Chem Mill and SSB area, additional localized models were developed in a manner analogous to the overall site model. Ground water transport was estimated by calibrating the USGS's three-dimensional modular flow program developed by McDonald and Harbaugh (1988) and contaminant transport was determined with a three-dimensional transport code developed by SSP&A.

Contaminants simulated in the Chem Mill area include TCE, TCA, and hexavalent chromium. Contaminant transport modeling of the Chem Mill area simulated potential corrective measures. These included (1) perforation and withdrawal of ground water from all four sumps in the Chem Mill basement and (2) perforation and ground water withdrawal from all four sumps (as in 1) and pumpage of ground water from 9 wells located in areas of ground water contamination.

Model simulations indicated that pumping water from the sumps is an effective method of removing TCE and TCA from the ground water. If a pumping alternative is used, TCA is predicted to decrease below the maximum contaminant level (MCL) in less than 8 years. Additional wells are required to achieve comparable removal of chromium from the vicinity of the Hydrostatic Test Tank. Hexavalent chromium is not easily removed due to its limited mobility in the ground water as compared to the VOCs.

Modelling at the SSB simulated a scenario involving pumping of ground water from seven wells in the area all of which show signs of ground water contamination. The total flow to the seven wells in the remedial alternative was less than 0.1 gpm. Furthermore, based upon monitoring data, the model predicted the acetone concentrations would drop below 2,400 ppb (the  $10^4$  risk level) in 10 years. Addition of extraction wells would not appreciably alter this outcome with respect to the time required to achieve the cleanup level.

Simulations of remedial alternatives in the Evaporation Pond area considered the transport of TCA. Modelling results indicated that TCA concentrations in the alluvial ground water would be decreased significantly in 10 years under a scenario of source control by fixation and capping. Source control does not have a significant impact on bedrock TCA concentrations in this same time frame due to the lower ground water velocity.

## **5.0 SUMMARY OF SITE RISK**

A Public Health Evaluation (PHE) and Ecological Assessment (EA) were performed for the MMAG site by Clement Associates, Inc. (CAI, 1990). The information presented in this section is summarized from that report. The purpose of the PHE and EA was to evaluate the risk to human health and the environmental impacts which might be associated with the MMAG site under current or potential future conditions of land use. The PHE and EA constitute a baseline risk assessment. They are based on the assumption that no remedial action or mitigation procedures are instituted or in place that might lower the concentrations or reduce the effects of contamination identified in various media on the site. The risks associated with the site were evaluated to facilitate selection of remedial actions at the site.

### **5.1 CONTAMINANT IDENTIFICATION INFORMATION**

Contaminant concentrations used in the risk assessment were of two types:

1. Validated sampling data
2. Data generated by computer modelling that resulted in estimated chemical concentrations at locations downstream from known sources for future and present conditions

These data were used to identify the media and contaminants of concern, to calculate the associated health risks, and to evaluate potential environmental effects.

#### **5.1.1 Media of Concern**

Three media of concern were identified because they could be pathways of exposure to contaminants originating on the MMAG site: soil, surface water, and ground water. The basis for selection of these media was the presence of significant concentrations of contaminants and the potential for human exposure and environmental effects associated with these concentrations.

Air was not selected as a media of concern because air monitoring data showed no inorganic contamination and insignificant contamination (low concentrations detected only once) of VOCs. Transport of non-volatile compounds by airborne dusts was not considered in the risk assessment except for the case of on-site construction workers involved in activities that disturb subsurface soil for limited periods of time.

Sediment was not considered a medium of concern because sampling data indicated no significant contamination within that medium.

#### 5.1.2 Contaminants of Concern in Each Medium

Chemicals of potential concern for the risk assessment were selected by a process of elimination. Sampling data for each chemical were scrutinized and compared to selection criteria. The following criteria were used to eliminate a detected contaminant from further consideration:

- The contaminant was not specifically identified in the sampling results but was reported only as a chemical class.
- No toxicity criteria exist with which to evaluate the health or environmental effects of the identified chemical.
- The chemical concentration was not above local or regional background concentrations.
- The chemical was detected with a frequency of less than 5 percent or only once, and was not detected frequently above background in related media.
- The sampling data did not meet Level 4 criteria for Data Quality Objectives (DQOs) as defined by EPA (EPA, 1987) and the chemical was not detected above background levels in related media.

In addition, only dissolved metals were considered in ground water (that is only the metals detected in filtered ground water samples) with the exception of hexavalent chromium. Total metals (metals detected in unfiltered samples) were considered in selection of chemicals of concern for surface water. Radioactive parameters were not considered because of the proximity of uranium-bearing geological zones and minimal historic use of radioactive compounds on the site.

Chemicals of potential concern were identified separately in each of 11 different geographic areas for ground water, 9 different areas of surface flow for surface water, and 9 geographic areas for soil contamination. Up to 53 chemicals were determined to be of potential concern in each of these areas, with the largest number being present in the soils and ground water in the Inactive Site area. Classes of chemicals designated to be of concern included:

- Chlorinated aliphatic organic compounds accounted for most of the chemicals of concern considered and included TCE, tetrachloroethylene, 1,1,1-TCA and a suite of transformation products including vinyl chloride
- Aromatic compounds including benzene, toluene, phenols, and xylenes
- Hydrazines and the transformation product NDMA

- Polycyclic aromatic hydrocarbons (PAH) including benzol(a)pyrene
- Polychlorinated biphenyls (PCBs)
- Inorganic compounds including fluoride, nitrates and nitrites, cyanide, and at least 16 metals including hexavalent chromium, arsenic, lead, cadmium, and beryllium

The complete listing of chemicals of concern for each media in each geographic area is provided in Tables 2-5 through 2-8 in the PHE (CAI, 1990).

### 5.1.3 Concentrations of Chemicals

In general, concentrations of chemicals are highest in ground water and soil and lowest in surface water on the site. Of the 11 geographic areas on the site that were investigated, the most contaminated areas both in numbers of contaminants and concentrations of contaminants are the Inactive Site and the M3 area. The Filter Gulch area is also associated with relatively more contaminants or higher concentrations of contaminants than other site areas.

Concentrations of organic contaminants in ground water were generally in the ppb range but a large number of organic and inorganic contaminants were found in parts per million (ppm) concentrations in at least one geographic area including:

- The ketones acetone and 2-butanone
- The chlorinated aliphatic compounds methylene chloride, TCE, tetrachloroethylene, 1,1,1-TCA and the transformation products cis- and trans-1,2-DCE, 1,1-DCE, and 1,1-DCA
- The aromatic compounds toluene and total xylenes
- The nitrogen-containing organic compound monomethyl hydrazine
- Inorganic compounds including the metals hexavalent chromium, total chromium, arsenic, iron, manganese, mercury, silver, copper, aluminum, the halogen fluoride, the nitrogen-containing inorganic compounds nitrate and nitrite, and ammonia

Of the organic contaminants, TCE contamination of ground water was the highest and most widespread: TCE was detected in nine ground water study areas and was found in ppm concentrations in five ground water study areas on-site. Related chlorinated compounds and transformation products were also widespread, although not generally in such relatively high concentrations.

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Hexavalent chromium was detected in six study areas although it was eliminated as a chemical of potential concern for the risk assessment in three study areas. It was found in ppm concentrations in two areas; the M3 area and the Inactive Site.

The important transformation products vinyl chloride and NDMA were each found in concentrations greater than 100 ppb in the Filter Gulch area and the Inactive Site area, respectively. Vinyl chloride was also detected in one other ground water study area.

The contaminant concentrations in ground water used in the risk assessment are tabulated in Tables A-1 through A-11 in the PHE (CAI, 1990).

The number and concentration of soil contaminants was highest in the Inactive Site and M3 areas where a total of 44 chemicals were detected in ppm concentrations including:

- TCE, tetrachloroethylene, and related compounds
- five benzene-related compounds
- eleven PAHs
- four PCBs
- eight metals including hexavalent chromium
- Other inorganic compounds including cyanide

Additionally, in these two areas the metals aluminum, barium, copper, and total chromium (including hexavalent) were measured in parts per thousand concentrations (that is for every kilogram of soil there was one gram of these metals at the sampled location). Vinyl chloride was also detected in these two areas at a concentration greater than 100 ppb.

Soil concentrations of contaminants detected in all study areas are tabulated in Tables A-23 through A-31 of the PHE (CAI, 1990).

Surface water on-site was associated with concentrations of chemicals in the ppb range and with fewer detected compounds, primarily metals and a few organic chemicals, most notably TCE. Iron and nitrate were detected at least once in on-site surface water in the ppm range. The aliphatic compound TCE was detected at a maximum concentration of greater than 100 ppb in Lariat Gulch surface water. Vinyl chloride was detected in the Filter Gulch surface water at approximately 3 ppb.

Tables A-12 through A-22 of the PHE present the complete results of contaminant concentrations detected in surface water including the South Platte River sampling results (CAI, 1990).

## **5.2 EXPOSURE ASSESSMENT INFORMATION**

Human exposure to contaminants of concern identified on the MMAG site were assessed based on the presence of contaminants in the three primary media of concern (soil, ground water, and surface water) and the likelihood of human contact with those media by inhalation, ingestion, and dermal contact. Exposures to non-human species were evaluated based on chemical concentrations in soil and surface water and the likelihood of direct contact with these contaminants by wildlife or plant species. EPA required the evaluation of domestic use of ground water on-site as a reasonable maximum exposure scenario.

### **5.2.1 Exposure Pathways**

For humans, the following major pathways were evaluated:

- Ingestion of venison or fish that had contacted site contaminants in soils and surface water on or proximate to the MMAG site
- Direct contact with contaminated soils in different geographic areas on-site by incidental ingestion, inhalation, and dermal absorption
- Domestic use of surface or ground water at various sampled exposure points resulting in exposure by ingestion and inhalation of contaminants volatilizing from water during use

Nineteen potential pathways were initially considered but only 11 were evaluated as likely to be complete. All pathways considered are tabulated in Tables 4-2 and 4-6 of the PHE (CAI, 1990).

For wildlife and plants the following exposure pathways were identified:

- Direct contact with contaminants in soil by inhalation, ingestion, aerial deposition and absorption (such as deposition on plants), or dermal exposure (such as during burrowing behavior)
- Direct contact with contaminants in surface water by ingestion, by dermal absorption during bathing or swimming, or for fish during respiration through gills
- Direct contact with contaminated sediments by wading animals or birds, or by ingestion by bottom-feeding invertebrates or fish
- Indirect contact with contaminants originating on the MMAG site by ingestion of contaminated prey or vegetation



Most of these pathways were considered only qualitatively in the assessment because data are lacking for quantitative evaluation.

### **5.2.2 Potential Exposed Populations**

Potentially exposed human populations were identified to include the following:

- Deer hunters on the site and persons fishing in the nearby South Platte River or the Division of Wildlife ponds
- Workers at the MMAG site working at specific outdoor locations
- Domestic users of water from the Chatfield Reservoir downstream from the site
- Hypothetical residents living on-site

Animal and plant populations potentially exposed include:

- Rare, threatened, or endangered species including a plant rare only in Colorado, the annual threeweed, and two Federally-listed endangered species: the bald eagle and the peregrine falcon
- Plant, terrestrial animal, and bird species associated with the variety of habitats on or proximate to the site that range from grasslands to mountain habitats and include riparian habitats along the South Platte River and the Chatfield Reservoir
- Aquatic species in the South Platte River and the Chatfield Reservoir including game fish and the populations of species that support them
- The populations of fish, invertebrate, and plant species that may live or range into the on-site streams of Brush Creek, Dry Creek, Filter Gulch, and Lariat Gulch some of which have perennial flow in certain portions of their courses through and off the site

### **5.2.3 Monitoring or Modelling Data and Assumptions Used to Characterize Exposure Point Concentrations**

Both monitoring and modelling data were used to estimate exposure concentrations. Monitoring data from on-site soil, surface water, ground water sampling, and air monitoring data were used for most on-site exposure points. Off-site sampling data that was collected included surface water samples collected from the Kassler area, the South Platte River, and the Last Chance Ditch. Geometric mean and maximum values were used to evaluate the average and plausible maximum exposures, respectively.

The migration of contaminants in ground water was modelled from seven major source areas assuming linear adsorption. Contaminant concentrations were estimated by modelling for off-site exposure points and for some ground water points on-site. For modelling purposes, the two ground water extraction and treatment systems currently operating were assumed to not be in operation. Organic compounds were primarily assumed to move at the linear velocity of water while retardation coefficients were used to model the movement of inorganic compounds and metals.

The volatilization of chemicals from surface water was modelled assuming exponential decay of concentrations. The volatile organic transfer coefficient was estimated to be 0.4 based on-site-specific data. Volatilization of contaminants from soil was predicted based on chemical-specific vapor pressure and/or Henry's Law constants. Emissions factors and a simple box model were used to estimate contaminant concentrations in air as a result of soil-disturbing activities such as construction.

Concentrations of chemicals in the Chatfield Reservoir were estimated based on predicted concentrations in the South Platte River multiplied by 0.85 to account for the contribution of other sources to the reservoir. River concentrations were based on the estimated location where all chemical contaminants from the site would have discharged.

Contaminant concentrations in venison were estimated using modified transfer coefficients for uptake of chemicals in beef cattle. Bioconcentration factors in fish were based on literature values or were estimated if not in the published literature.

For a complete account of data and assumptions used, the PHE should be consulted (CAI, 1990).

#### **5.2.4 Assumptions of Exposure Frequency and Duration**

The assumptions regarding exposure frequency and duration for the various pathways evaluated are presented in Table 5-1 of this report.

### **5.3 CURRENT AND FUTURE USE SCENARIOS**

#### **5.3.1 Assumptions**

The baseline risk assessment relied primarily on standard assumptions of exposure available in the Exposure Factors Handbook (1988). Assumptions concerning average body weight,

TABLE 5-1

**Assumptions of Exposure Frequency and Duration Used  
for Baseline Risk Assessment of MMAG Site Contaminants**

Exposed Population	Routes of Exposure	Exposure Frequency		Exposure Duration	
		Average	Plausible Maximum	Average	Plausible Maximum
<u>Current Conditions</u>					
Deer hunters	Ingestion of venison	3 times/wk	4 times/wk	9 yr	30 yr
Persons fishing in river or ponds nearby	Ingestion of fish	Daily <sup>(a)</sup>	Daily	9 yr	30 yr
Domestic water users	Ingestion of water	Daily	Daily	9 yr <sup>(b)</sup>	30 yr
	Inhalation during showering	Daily	Daily	9 yr	30 yr
<u>Future conditions</u>					
On-site MMAG workers	Dermal contact with soil	180 d/yr	180 d/yr	1 yr	3 yr
	Incidental ingestion of soil	180 d/yr	180 d/yr	1 yr	3 yr
	Inhalation of contaminants in soil <sup>(c)</sup>	180 d/yr	180 d/yr	1 yr	3 yr
On-site construction workers	Dermal contact with soil	30 d	30 d	6 wk	6 wk
	Incidental ingestion of soil	30 d	30 d	6 wk	6 wk
	Inhalation of contaminants in soil	30 d	30 d	6 wk	6 wk
Future residents	Dermal contact with soil	80 d/yr	200 d/yr	9 yr	30 yr
	Incidental ingestion of soil	80 d/yr	200 d/yr	9 yr	30 yr
	Dermal contact with surface water	7 d/yr <sup>(d)</sup>	7 d/yr	9 yr	15 yr
	Use of on-site ground water (ingestion and inhalation)	Daily	Daily	9 yr	30 yr
	Use of on-site surface water (ingestion and inhalation)	Daily	Daily	9 yr	30 yr

TABLE 5-1.

**Assumptions of Exposure Frequency and Duration Used for  
Baseline Risk Assessment of MMAG Site Contaminants (Concluded)**

Exposed Population	Routes of Exposure	Exposure Frequency		Exposure Duration	
		Average	Plausible Maximum	Average	Plausible Maximum
Future residents (cont.)	Use of off-site ground water (ingestion and inhalation)	Daily	Daily	9 yr	30 yr
	Use of off-site surface water (ingestion and inhalation)	Daily	Daily	9 yr	30 yr
	Use of Kassler underground storage tank water	Daily	Daily	9 yr	30 yr
	Ingestion of fish with Kassler system operating	Daily <sup>a)</sup>	Daily	9 yr	30 yr

<sup>a)</sup> Daily consumption of fish was assumed because the consumption rate was based on an annual average divided by the number of days in a year.

<sup>b)</sup> For non-carcinogens only the 9 year case resulted in the greatest calculated exposure, so it was considered the plausible maximum case and the 30 year case was considered the average case.

<sup>c)</sup> For inhalation, exposure was assumed to occur for 4 hours per day for each of the 180 days per year

<sup>d)</sup> For children wading in on-site streams, exposure was assumed to last for 2.6 hours per day from ages 3 through 12 or 3 through 18.

consumption rates for water and fish, showering times, inhalation rates, rates of incidental ingestion of soil, body surface area, average lifetime, time spent swimming or wading, and residence duration were all based on data from the handbook. Other published literature or professional judgement were used when data were not available in the handbook. The PHE presents the assumptions used for exposure in Chapter 5 and in Appendix C (CAI, 1990).

### 5.3.2 Current Use Scenario

The exposed populations considered in the current use scenario are listed in Table 5-1. Access to the site is restricted under current conditions.

### 5.3.3 Future Use Scenario

The exposed populations considered in the future use scenario are listed in Table 5-1. Currently unused portions of the site are assumed to be storage areas resulting in employee exposure to high contamination. An alternative assumption included the site being developed for residential use, exposing construction workers to subsurface soils and residents to contaminated media. The Kassler system was assumed to resume operation in order to evaluate its effect on contaminants reaching the South Platte River.

## 5.4 TOXICITY ASSESSMENT INFORMATION

### 5.4.1 Slope Factors

Slope factors (SF) have been developed by the EPA Carcinogenic Assessment Group (CAG) for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. SFs, which are expressed in units of  $(\text{mg/kg/day})^{-1}$ , are multiplied by the estimated intake of a potential carcinogen, in  $\text{mg/kg/day}$ , to provide an upper bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of risks calculated from the SF. Use of this approach makes underestimating the actual cancer risk highly unlikely. SFs are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied. SFs for the major contaminants at the MMAG site are presented in Table 5-2.

TABLE 5-2.

**SLOPE FACTORS<sup>(a)</sup> USED IN THE BASELINE RISK ASSESSMENT FOR MMAG SITE**

Chemical	Slope Factor (mg/kg/day) <sup>1</sup>		Weight-of-Evidence Classification <sup>(b)</sup>
	Oral	Inhalation	
Benzene	0.029	0.029	A
1,1 - Dichloroethane	0.091	—	B2
1,1 - Dichloroethylene	0.6	1.2	C
Methylene chloride	0.0075	0.014	B2
N - nitrosodimethylamine	51	51	B2
Polychlorinated bipheyls	7.7	7.7	B2
Polycyclic aromatic hydrocarbons	11.5	6.1	B2
Tetrachloroethylene	0.051	0.0033	B2
Trichloroethylene	0.011	0.0046	B2
Unsymmetrical dimethylhydrazine	1.88	—	B2
Vinyl chloride	2.3	0.295	A
Cadmium	—	6.1	B1
Chromium, hexavalent	—	41	A
Lead	—	—	B2

<sup>(a)</sup> Slope factors are only presented for contaminants classified as to carcinogenicity, and that contributed significantly to MMAG site contamination as determined by the following criteria: concentration exceeded a Federal Standard and/or the contaminant contributed to a cancer risk of  $> 1 \times 10^{-4}$  or hazard index  $> 1$  in the MMAG baseline risk assessment. The complete list of slope factors for chemicals of potential concern can be found in Tables 3-1 and 3-2 in the PHE (CAI, 1990).

<sup>(b)</sup> Weight-of-Evidence Classes are as follows:

- A = Human Carcinogen, sufficient evidence from human epidemiologic studies
- B1 = Probable Human Carcinogen, limited human evidence and adequate animal evidence
- B2 = Probable Human Carcinogen, inadequate human evidence and adequate animal evidence
- C = Possible Human Carcinogen, limited animal evidence in the absence of human evidence
- D = Not classified as to human carcinogenicity
- E = Evidence of noncarcinogenicity

#### 5.4.2 Reference Dose

Reference doses (RfDs) have been developed by EPA to indicate the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg/day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of chemicals from environmental media (such as the amount of a chemical ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (that is, to account for the use of animal data to predict effects on humans). These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur. RfDs for the major contaminants at the MMAG site are presented in Table 5-3.

#### 5.4.3 Explanation of Toxicity Information

The SFs and RfDs were used to quantitatively characterize the health risk associated with the contaminants of concern. Examination of Tables 5-2 and 5-3 reveals that SFs vary by up to 4 orders of magnitude (a factor of 10,000) and that RfDs also vary substantially. A large SF indicates that a low exposure or intake produced carcinogenic effects in the study or studies used to determine the SF and/or that the uncertainty associated with the carcinogenicity of the chemical is high. A small SF indicates that at low exposures or intakes the carcinogenic effects were low and/or that the uncertainty is low. For RfDs, the lower the RfD the greater the potential for adverse effects at low intakes and/or the higher the uncertainty associated with the RfD. Generally, high SFs and low RfDs are associated with chemicals that have shown a high potential for carcinogenic or other adverse effects, at least in animal studies. As an example, the RfD for TCE is relatively low indicating a high potential for adverse effects to be associated with exposure to this contaminant. However, the SF for vinyl chloride, a transformation product of TCE, is much higher than the SF for TCE, indicating that at similar exposures there may be a higher potential for carcinogenic effects to occur from vinyl chloride than from TCE.

Qualitative information regarding the types of toxicity or carcinogenicity of the 53 compounds of concern were provided in toxicity profiles presented in Appendix B of the PHE.

### 5.5 RISK CHARACTERIZATION INFORMATION

Risk was characterized for carcinogenic and noncarcinogenic effects that could potentially result from exposure to chemical contaminants detected on the MMAG site.

TABLE 5-3.

REFERENCE DOSES<sup>(a)</sup> USED IN THE BASELINE RISK ASSESSMENT FOR MMAG SITE

Chemical	Reference Dose (mg/kg/day)	
	Oral	Inhalation
1,1 - Dichloroethane	0.1	0.1
1,1 - Dichloroethylene	0.009	—
Methylene chloride	0.06	—
Polycyclic aromatic hydrocarbons	0.4	—
Tetrachloroethylene	0.01	—
1,2,4 - Trichlorobenzene	0.02	0.003
1,1,1 - Trichloroethane	0.09	0.3
Trichloroethylene	0.00735	—
Ammonia	0.97	0.36
Cadmium	0.001	—
Chromium, hexavalent	0.005	—
Chromium, trivalent	1	—
Copper	0.037	0.01
Lead	0.0006	—

<sup>(a)</sup> Only chemicals with established reference doses and which meet the following criteria are presented: concentration on MMAG site exceeded a Federal Standard or the contaminant contributed to a cancer risk of  $> 1 \times 10^{-4}$  or a hazard index  $> 1$  in the MMAG baseline risk assessment.



### 5.5.1 Quantified Carcinogenic Risks for Each Contaminant of Concern in Each Pathway

Excess lifetime cancer risks are determined by multiplying the intake level with the cancer slope factor. These risks are probabilities that are generally expressed in scientific notation (that is,  $1 \times 10^{-6}$ ). An excess lifetime cancer risk of  $1 \times 10^{-6}$  indicates that, as a plausible upper bound, an individual has a one in one million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site.

The carcinogenic risk associated with each of the 53 chemical contaminants of concern for each pathway and exposure point is presented in Tables E-1 through E-66 of the PHE (CAI, 1990). Table 5-4 presents a summary of risk information for 14 of the chemicals of concern. Each of the chemicals in Table 5-4 meets the following criteria for inclusion:

- The chemical has been classified by EPA as a known or suspected carcinogen
- The chemical was described in the PHE as contributing to a cancer risk of greater than or equal to  $1 \times 10^{-6}$  for at least one exposure pathway.
- The concentration of the chemical exceeded a Federal standard (such as the MCL for drinking water) in at least one sampling location at the MMAG

### 5.5.2 Combined Carcinogenic Effects

The combined risk for exposure to all of the chemicals of concern for a particular pathway and exposure point are given in Tables 8-1 to 8-4 of the PHE (pp. 8-6 to 8-17, CAI, 1990).

The only exposure pathway considered for current land use conditions that is associated with a risk greater than  $1 \times 10^{-6}$  according to the assumptions used in the PHE is domestic use of water from the Chatfield Reservoir, but only for the plausible maximum intake case. The estimated average intake results in a risk of  $5 \times 10^{-7}$ . Modelling estimates rather than measured data were used for calculating these risks. No direct on-site exposures were considered probable.

When future land use conditions were considered, however, on-site exposures through direct contact with or inhalation of contaminants in soil resulted in the plausible maximum intake producing a cancer risk of greater than  $1 \times 10^{-6}$  in 4 out of 6 scenarios. In only one of these scenarios did the risk associated with the estimated average intake also exceed  $1 \times 10^{-6}$ . In all 5 cases the risk was within the range of  $1 \times 10^{-6}$  and  $7 \times 10^{-5}$ , or one in one million to seven in one hundred thousand. Direct contact with surface water was not associated with a risk greater than  $7 \times 10^{-8}$  for even the maximum detected concentrations of chemicals in surface water on-site. Except for the inhalation

TABLE 5-4

Contribution of Individual Chemicals to Cancer Risk  $\geq 1 \times 10^{-4}$  at  
Exposure Points for the MMAG Site

Chemical	Maximum calculated risk from MMAG site contamination	Number of exposure points where risk $\geq 1 \times 10^{-4}$	Routes and pathways of exposure associated with $\geq 1 \times 10^{-4}$ risk
Benzene	$5 \times 10^{-3}$	5	Future domestic use of ground water on-site <sup>(b)</sup> Future domestic use of ground water off-site <sup>(c)</sup>
1,1-Dichloroethane	$2 \times 10^{-3}$	16	Future domestic use of ground water on-site <sup>(b)</sup> Future domestic use of surface water on-site Future domestic use of ground water off-site <sup>(c)</sup>
1,1-Dichloroethylene	$2 \times 10^{-1}$	32	Future domestic use of ground water on-site <sup>(b)</sup> Future domestic use of surface water on-site Future domestic use of ground water off-site <sup>(c)</sup>
Methylene chloride	$3 \times 10^{-2}$	18	Future inhalation of chemicals by workers from on-site surface soils <sup>(c)</sup> Future inhalation of chemicals by workers from on-site surface subsoils <sup>(c)</sup> Future domestic use of ground water on-site Future domestic use of surface water on-site Future domestic use of ground water off-site <sup>(c)</sup>
N-Nitrosodimethylamine	$1 \times 10^{-1}$	20	Current domestic use of Chatfield Reservoir water <sup>(c)</sup> Future domestic use of ground water on-site Future domestic use of ground water off-site <sup>(c)</sup> Future domestic use of Kassler storage tank water <sup>(c)</sup>
Polychlorinated biphenyls	$1 \times 10^{-4}$	3	Future direct contact by workers with subsurface soils on-site Future direct contact by residents with surface soils on-site Future domestic use of ground water on-site

TABLE 5-4

**Contribution of Individual Chemicals to Cancer Risk  $\geq 1 \times 10^{-6}$  at  
Exposure Points for the MMAG Site (Concluded)**

Chemical	Maximum calculated risk from MMAG Site contamination	Number of exposure points where risk $\geq 1 \times 10^{-6}$	Routes and pathways of exposure associated with $\geq 1 \times 10^{-6}$ risk
Polycyclic Aromatic Hydrocarbons	$2 \times 10^{-5}$	2	Future direct contact by workers with subsurface soils on-site  Future inhalation of chemicals from subsurface soils by workers on-site <sup>(a)</sup>
Tetrachloroethylene	$7 \times 10^{-3}$	5	Future direct contact with subsurface soils by workers on-site Future inhalation of chemicals in subsurface soils by workers on-site <sup>(a)</sup> Future domestic use of ground water on- site <sup>(a)</sup> Future domestic use of ground water off- site <sup>(a)</sup>
Trichloroethylene	$1 \times 10^{-1}$	40	Future direct contact with subsurface soils by workers on-site Future inhalation of chemicals in subsurface soils by workers on-site <sup>(a)</sup> Future domestic use of ground water on- site <sup>(a)</sup> Future domestic use of surface water on- site Future domestic use of ground water off- site <sup>(a)</sup>
Unsymmetrical Dimethyl hydrazine	$4 \times 10^{-3}$	8	Future domestic use of ground water on- site <sup>(a)</sup>
Vinyl chloride	$8 \times 10^{-4}$	10	Future domestic use of ground water on- site <sup>(a)</sup> Future domestic use of surface water on- site Future domestic use of ground water off- site <sup>(a)</sup>
Cadmium	None	None	None reported <sup>(d)</sup>
Chromium, hexavalent	None	None	None reported <sup>(d)</sup>
Lead	None	None	None reported <sup>(d)</sup>

<sup>(a)</sup> Unless otherwise noted, measured concentrations of contaminants were used to calculate risk.

<sup>(b)</sup> Ground water from alluvium and bedrock was calculated. Measured concentration of contaminants in alluvial ground water were used to calculate risk, while modelling estimates of contaminant concentrations were used for the risk from bedrock ground water.

<sup>(c)</sup> Based on modelling estimates rather than measured data.

<sup>(d)</sup> The inorganic metals cadmium, chromium and lead were reported to exceed Federal Maximum Contaminant Levels in on-site ground water, but no estimated intakes or risks were presented for these metals in Appendix E of the PHE (CAI, 1990).

pathway, these risks were calculated using measured concentrations of contaminants. Concentrations of soil contaminants in air were estimated by computer modelling as described previously.

The use of ground water on-site for domestic purposes including ingestion and showering would be associated with relatively high cancer risks depending on the exposure point. At 11 out of 14 on-site exposure points (80 percent), domestic use of the ground water would be associated with an upper-bound cancer risk greater than  $1 \times 10^{-4}$  (greater than 1 in 10,000) for both the estimated average intake and plausible maximum intake. Five of the exposure points where the calculated risk was greater than or equal to  $1 \times 10^{-4}$  were alluvial ground water; 6 were ground water points associated with bedrock formations. Concentrations in alluvial ground water were measured, while contaminant concentrations in ground water associated with bedrock formations were based on modelling estimates. The upperbound cancer risk associated with domestic use of ground water ranged from a low of 1 in 100,000 ( $1 \times 10^{-5}$ ) to a high of 1 in 10 ( $1 \times 10^{-1}$ ). At 5 of the 14 exposure points (36 percent), the upper-bound cancer risk associated with domestic use of ground water was estimated to be greater than 1 in 1,000 ( $1 \times 10^{-3}$ ); 3 of these points were alluvial ground water points and 2 were ground water points associated with bedrock formations.

The domestic use of surface water on-site was associated with a lower cancer risk that ranged from a low of  $3 \times 10^{-4}$  for the average intake at one surface water exposure point to  $7 \times 10^{-5}$  for the plausible maximum at another surface water location based on measured data.

Domestic use of ground water off-site, was calculated using modelling estimates of site-boundary concentrations. Off-site ground water use was associated with an upper-bound cancer risk that ranged from 9 in 100,000 for the average case from a Brush Creek well to 8 in 1,000 for the plausible maximum case from a Filter Gulch well. The average and plausible maximum cases differed by about one order of magnitude (a factor of 10). Off-site surface water taken from Brush Creek, if used domestically, would be associated with a 3 in 100,000 (average case) to 1 in 10,000 (plausible maximum case) upper bound-cancer risk based on modelling estimates of contaminant concentrations.

If the Kassler system were to be put back in operation and water were supplied from the Kassler underground storage tank without being treated, the risk would be similar to current use of the Chatfield Reservoir for both the average and plausible maximum intakes ( $6 \times 10^{-7}$  to  $3 \times 10^{-6}$ ) according to modelling estimates.

### 5.5.3 Noncarcinogenic Effects for Each Contaminant in Each Pathway

The relative potential for noncarcinogenic effects to result from exposure to a single contaminant in a single medium is expressed as the hazard quotient (HQ) (that is, the ratio of the estimated intake derived from the contaminant concentration in a given medium to the contaminant's RfD). When the HQ exceeds 1, the estimated intake exceeds the RfD. The potential for adverse effects to occur increases as the HQ increases above 1. By adding the HQ's for all contaminants within a medium or across all media to which a given population may reasonably be exposed, the Hazard Index (HI) can be generated. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media.

The HQs for all contaminants of concern for each pathway and exposure point are presented in Tables E-1 through E-66 of the PHE (CAI, 1990). In Table 5-5 that follows, the noncarcinogenic hazard information is briefly summarized for 12 contaminants of concern that were described in the PHE as contributing to an HI of greater than 1 for at least one pathway and location.

### 5.5.4 Combined Noncarcinogenic Effects

The HIs for the combined exposure to the contaminants of concern for each exposure pathway and exposure point are presented in Tables 8-1 through 8-4 of the PHE (pp. 8-6 through 8-17, CAI, 1990). No current exposures are estimated to result in an HI that exceeds 1. No direct on-site exposures were considered probable under current conditions.

Direct contact with or inhalation of contaminants from subsurface soils on-site in the future were predicted to result in an HI of approximately 6. No other direct contact or inhalation exposures were predicted to be associated with an HI greater than 1. The inhalation pathway was evaluated using modelling estimates, rather than measured data.

The domestic use of ground water on-site was associated with an HI greater than or equal to 1 at 13 out of 14 exposure points (93 percent) for the average case. The average intake resulted in an HI that ranged from 0.5 to 400 and the HIs for the plausible maximum intake ranged from 2 to 800 for all 14 exposure points. The exposure points were divided between 8 alluvial ground water points, which were actually sampled, and 6 bedrock ground water points where contaminant concentrations were based on modelling estimates. Two out of seven on-site exposure points where surface water was sampled would be associated with an HI greater than 1 but less than 5, if the water was used domestically.

**TABLE 5-5**  
**Contribution of Individual Chemicals to Hazard Index (HI) > 1 at**  
**Exposure Points for the MMAG Site**

Chemical	Maximum calculated hazard quotient from MMAG site contamination	Number of exposure points where HI exceeds 1	Routes and pathways of exposure associated with HI > 1 <sup>(a)</sup>
1,1-Dichloroethane	4	2	Future domestic use of ground water on-site <sup>(a)</sup>
1,1-Dichloroethylene	180	5	Future domestic use of ground water on-site <sup>(a)</sup> Future domestic use of ground water off-site <sup>(a)</sup>
Methylene chloride	87	4	Future domestic use of ground water on-site <sup>(a)</sup>
Tetrachloroethylene	210	2	Future domestic use of ground water on-site <sup>(a)</sup>
1,2,4-Trichlorobenzene	15	3	Future inhalation by workers of chemicals in subsurface soils on-site <sup>(1)</sup> Future domestic use of ground water on-site <sup>(a)</sup>
Trichloroethane	95	11	Future domestic use of ground water on-site <sup>(a)</sup> Future domestic use of ground water off-site <sup>(a)</sup>
Trichloroethylene	6300	18	Future direct contact with subsurface soils by workers on-site <sup>(a)</sup> Future use of ground water on-site Future domestic use of surface water on-site <sup>(a)</sup> Future use of ground water off-site <sup>(a)</sup>
Ammonia	4	2	Future domestic use of ground water on-site <sup>(a)</sup> Future domestic use of surface water on-site
Cadmium	1.2	1	Future domestic use of ground water on-site <sup>(a)</sup>

**TABLE 5-5**

**Contribution of Individual Chemicals to Hazard Index (HI) > 1 at Exposure Points for the MMAG Site (Concluded)**

Chemical	Maximum calculated hazard quotient from MMAG site contamination	Number of exposure points where HI exceeds 1	Routes and pathways of exposure associated with HI > 1
Chromium	250 <sup>(a)</sup>	6 <sup>(a)</sup>	Future domestic use of ground water on-site <sup>(b)</sup> Future domestic use of surface water on-site  Future domestic use of ground water off-site <sup>(c)</sup>
Copper	3	1	Future domestic use of ground water on-site <sup>(b)</sup>
Lead	110	5	Future direct contact with subsurface soils by workers on-site Future domestic use of ground water on-site <sup>(b)</sup> Future domestic use of surface water on-site

<sup>(a)</sup> Unless otherwise noted, measured concentrations of contaminants were used to calculate the HI.

<sup>(b)</sup> Ground water from all alluvia and bedrock formations was evaluated. Measured concentrations of contaminants in alluvial ground water were used to calculate the HI, while modelling estimates of contaminant concentrations were used to calculate the HI associated with water in bedrock.

<sup>(c)</sup> Based on modelling estimates rather than measured data.

<sup>(d)</sup> The HI reported were listed only as "chromium" but the reference dose used was for hexavalent chromium.

Based on modelling results for off-site ground water exposure points, two out of three locations would be associated with an HI ranging from 10 (average case) to 70 (plausible maximum case). The third point would be associated with an HI of 0.8 to 3. Off-site surface water locations and the Kassler underground storage tank water were associated with HIs less than 1 according to modelling estimates.

#### **5.5.5 Sources of Uncertainty**

Significant sources of uncertainty for any risk assessment include the following:

- Sampling data may be biased by technical or analytical limitations and models used to estimate concentrations at unsampled locations require many assumptions that may not exactly represent site characteristics.
- Toxicity values such as SFs and RfDs may be based on studies that require extrapolation from results of animal studies to effects in humans, extrapolation of high-dose exposures to much lower environmental exposures, and results from homogenous animal populations to variable human populations with a wide range of sensitivities.
- Exposure assumptions used to calculate intakes may over- or underestimate actual exposures for any one individual.

Therefore, conservative assumptions are used in risk assessment so that the calculated risk will more likely overestimate the risk than under estimate the risk.

Uncertainties that are specific to this risk assessment include the following:

- All off-site and some on-site concentrations were based on modelled rather than measured data
- No decay or transformation of contaminants with time and transport were included in modelling assumptions.

The last point may be particularly important at the MMAG site because concentrations of two contaminants, vinyl chloride and NDMA, are not known to have been used on the site but that are known to be transformation products of site contaminants shown in the risk assessment to contribute significantly to the calculated cancer risks.



### 5.5.6 Risk Assessment Conclusions

Chemical contamination at the MMAG site is widespread in soil and ground water. Fifty-three contaminants of concern were identified in site soils, ground water, and surface water.

EPA has established a risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  as generally acceptable exposure levels for hazardous waste sites. Calculated cancer risks for the MMAG site exceeded the target range by 1 to 3 orders of magnitude (that is, 10 to 100 times) at between 40 percent and 70 percent of ground water exposure points located both on- and off-site, depending on whether average intake or plausible maximum intake assumptions were used, respectively. A hazard index of 1 was exceeded at 90 percent of ground water locations for the average case, indicating the need for concern regarding the potential for noncarcinogenic adverse health effects to occur if ground water were to be used domestically. Risks calculated from estimated exposures to ground water on-site were similar whether contaminant concentrations were directly measured or based on modelling estimates. The primary risk is associated with the chemicals listed in Tables 5-4 and 5-5.

Based upon modeling data, the plausible maximum intake estimated for the current use of Chatfield Reservoir water results in an upper bound cancer risk slightly greater than  $1 \times 10^{-4}$  as a result of NDMA contamination. This estimate of risk is based upon modeled or predicted concentrations, not measured values. This contaminant is a stable transformation product of unsymmetrical dimethyl hydrazine that was a chemical of concern in ground water on-site. Concentrations of vinyl chloride may increase significantly with time because it is a transformation product of various chlorinated solvents including TCE and tetrachloroethylene that are the major contaminants on the site. Risks associated with these compounds will also increase with time, if concentrations increase. Both vinyl chloride and NDMA are associated with SFs at least 10 times higher than the compounds from which they are formed.

### 5.6 ENVIRONMENTAL RISKS

Risks to aquatic life were partially evaluated by comparing contaminant concentrations with Federal and State of Colorado standards. Concentrations of silver, chromium, cyanide, aluminum, and fluoride exceed either Federal Ambient Water Quality Criteria or a Colorado standard for surface water in Brush Creek on the site. The locations are primarily intermittent streams. Chemical concentrations in the South Platte River are not estimated to exceed any Federal or State criteria. Sediments and surface water sampling indicated that contaminants are not being transported off site at significant concentrations and are not expected to impact aquatic life in the South Platte River.

### **5.6.1 Critical Habitats**

The brief qualitative evaluation performed did not identify any critical habitats or effects on critical habitats either on- or off-site.

### **5.6.2 Endangered or Threatened Species**

The brief qualitative evaluation performed identified one bald eagle nesting within a 3-mile radius and one rare plant that may occur on-site. No effects of site contamination on either species was projected.

## **6.0 DESCRIPTION OF ALTERNATIVES**

Remedial action alternatives in the feasibility study (FS) report were evaluated in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act, and the National Contingency Plan. Prior to evaluating remedial action alternatives, several preliminary evaluations occurred. Remedial action objectives were identified on the basis of the site characterization results. Response actions and associated technologies were considered and screened. The technology screening activities were based on relative effectiveness, implementability, and cost.

Preliminary remedial action alternatives were developed from the remaining technology process options. Alternatives were developed ranging from those eliminating the need for long-term management, to alternatives involving treatment that would permanently reduce the mobility, toxicity, or volume of the hazardous substances as their principal element. Containment options were also developed. During the preliminary remedial action alternatives analysis, several potential options were dropped.

Eight alternatives for soil remediation and four alternatives for ground water were developed in the FS (Eder, 1990). Upon completion of the initial screening phase of the FS, the number of soil alternatives was reduced to six for detailed analysis. The four ground water alternatives were also retained in the detailed analysis. Each of the retained alternatives is described in this section.

Remedial action objectives developed for the site are designed to address the principal threat and reduce the risks posed by potential health threats associated with the ground water. The remedial action objectives are as follows (clean up goals are described more fully in Section 8.0):

1. Reduce the threat posed by the Inactive Site contamination releases to the environment which impact ground water and surrounding soil and soil contamination associated with the Chemical Storage Tanks.
2. Restore the ground water to its beneficial uses by reducing contaminant levels to within acceptable standards for drinking water.

There are five soil alternatives from S-1 through S-5, and four ground-water alternatives GW-1 to GW-4, presented below. In-situ soil vapor extraction will not be discussed as a separate alternative because it was developed solely to address contamination in the Chemical Storage Tanks area. It is a component of all the soil alternatives, excluding no action.

#### SOIL ALTERNATIVES:

- S-1: No Action
- S-2: Dewater/RCRA Cap/In-situ Soil Vapor Extraction
- S-3: Dewater/Off-site Incineration and Disposal of Waste/Ex-situ Stabilization of Backfill and Alluvium/RCRA Cap/In-situ Soil Vapor Extraction
- S-4: Dewater/On-site Incineration of Backfill, Alluvium, and Waste/Off-site Disposal of Incinerated Waste/Ex-situ Stabilization of Incinerated Backfill and Alluvium/RCRA Cap/In-situ Soil Vapor Extraction
- S-5: Dewater/Off-site Incineration and Disposal of Waste/Thermal Extraction of Backfill and Alluvium/Ex-situ Stabilization of Backfill and Alluvium/RCRA Cap/In-situ Soil Vapor Extraction

#### GROUND WATER ALTERNATIVES:

- GW-1 No Action
- GW-2 Continued Operation of the Existing Recovery Well System/Treatment by Air Stripping, Carbon Adsorption, and Ion Exchange/Discharge to Brush Creek
- GW-3 Continued Operation of the Existing Recovery Well System/Installation of Additional Recovery Well System in Filter Gulch and Dry Gulch Upgradient from the Existing Recovery Well Systems/Treatment by Air Stripping, Carbon Adsorption, Ion Exchange, and/or UV Photolysis-Oxidation/Discharge to Brush Creek
- GW-4 Continued Operation of the Existing Recovery Well Systems/Installation of Additional Recovery Well Systems in Filter Gulch and Dry Gulch Upgradient from the Existing Recovery Well Systems/Addition of a Recovery Well System in the M3 Area/Treatment by Chemical Reduction, Precipitation, Clarification, Air Stripping, Carbon Adsorption, Ion Exchange, and/or UV Photolysis-Oxidation/Discharge to Brush Creek

## **6.1 ALTERNATIVE S-1: NO ACTION**

In accordance with Section 300.430(e) (6) of the NCP, the no action alternative must be considered in the FS. No action also serves as a baseline for comparison of other soil alternatives. No contaminants or contaminated media are removed or treated by the no action alternative, although natural attenuation processes are likely to occur.

No action, as it pertains to the Inactive Site and the Chemical Storage Tank areas, means that no activities intended to protect human health and the environment, including any remediation, would be taken. Contaminant migration from the Inactive Site and the Chemical Storage Tank areas would continue unrestricted.

Ground water monitoring would be conducted to track contaminant migration. No soil samples would be collected from either area. There would be no measures to prevent human exposure to contamination. A review of the threat to public health and the environment would be conducted at least every 5 years.

## **6.2 ALTERNATIVE S-2: DEWATER/RCRA CAP/IN-SITU SOIL VAPOR EXTRACTION**

The objectives of Alternative S-2 would be to reduce the potential for direct human contact with the Inactive Site soils, reduce infiltration of precipitation through the Inactive site ponds, remove perched water from the ponds, and remove volatile organic contaminants (VOCs) from the Chemical Storage Tank area. No treatment of waste, backfill, or contaminated alluvium would occur at the Inactive Site.

The area covering the Inactive Site and the area adjacent to it would be regraded to divert storm water run-on and enhance storm water run-off. The Inactive Site ponds are located on a topographic high; therefore, storm water flow would be diverted into the East Branch of Brush Creek drainage for flow to the north and the West Branch of Brush Creek/Dry Gulch drainage for flow to the south.

A series of wellpoints would be installed in the perched zones of the Inactive Site to extract water. The water would be temporarily stored in holding tanks and either trucked, pumped, or gravity fed to the MMAG's IWTP. The treated water would be discharged in accordance with MMAG's COPDES permit. The dewatering process would take approximately 2 to 3 months to complete.

A multi-layered cap is proposed for covering the Inactive Site area, which includes the five ponds and the area adjacent to the ponds. The cap would be sloped to divert surface flow away from the ponds.

Ground water monitoring would be conducted to monitor contaminant migration.

The cap would be maintained and no construction would occur on or near the cap. Since contaminants would remain at the Inactive Site, the site would be monitored and every five years EPA would review the remediation to assure that human health and the environment are protected.

In-situ soil vapor extraction would be used to remove VOCs from the Chemical Storage Tank area subsurface soil. A series of extraction wells connected to a vacuum pump would be installed in and around the Chemical Storage Tank area such that the cones of influence would extend over the entire contaminated area. A series of injection wells connected to a blower or vacuum pump would be placed in and around the Chemical Storage Tank area and used to induce air flow through the soil to strip and volatilize the VOCs into the air stream. Subsurface air, VOC vapors, and water vapors would migrate toward the vacuum extraction wells and be removed for collection and treatment.

Approximately 1.3 million gallons of perched water within the ponds would be removed, treated, and discharged to Brush Creek. Approximately 2,100 cy of waste, 9,700 cy of contaminated backfill, and 14,700 cy of contaminated alluvium would be left in-place.

Because both the Inactive Site and Chemical Storage Tank areas are covered, the Inactive Site by soil and the Chemical Storage Tank area by asphalt, the potential for direct contact exposure to contaminants is low. The installation of a cap at the Inactive Site would provide added insurance that the potential for direct human contact would be minimized. In-situ soil vapor extraction would effectively remove contaminants from the Chemical Storage Tank area so there would be no concern for exposure. Contaminants in the soil may continue to migrate from the Inactive Site and enter the ground water. However, infiltration is greatly reduced and contaminant migration is then reduced.

The uncertainty associated with Alternative S-2 are the ability to lower the ground water table enough to avoid intersecting the contamination below the ponds.

Alternative S-2 would comply with RCRA closure and RCRA cap requirements for surface impoundments and landfills. Air emissions from the in-situ soil vapor extraction process would meet ambient air quality standards. Perched water would be treated to permit discharge limits before being discharged to Brush Creek.

Alternative S-2 would be implemented in four months.

### **6.3 ALTERNATIVE S-3: DEWATER/OFF-SITE INCINERATION AND DISPOSAL OF WASTE/EX-SITU STABILIZATION OF BACKFILL AND ALLUVIUM/RCRA CAP/IN-SITU SOIL VAPOR EXTRACTION**

Alternative S-3 would be used to reduce contaminant migration from the Inactive Site into the ground water via removal and/or treatment of both organic and inorganic contaminants. In addition, the potential for direct human contact would be minimized by the placement of a cap. The RCRA cap would also reduce infiltration, which would enhance the long-term effectiveness of treatment. At the Chemical Storage Tank area, 99% removal of the organic contaminants would be anticipated, thereby eliminating the Chemical Storage Tank area as a potential source for ground water contamination.

This alternative would begin with the dewatering of the Inactive Site Ponds. After which, the contaminated areas would be excavated and material separated into waste, contaminated soil and uncontaminated backfill. Additionally, in-situ soil vapor extraction would be employed at the Chemical Storage Tank area to remove organic chemicals.

A series of wellpoints would be installed in the perched zones of the Inactive Site to extract water. The water would be temporarily stored in holding tanks and either trucked, pumped, or gravity fed to MMAG's IWTP. The treated water would be discharged in accordance with MMAG's COPDES permit. The dewatering process would take approximately 2 to 3 months to complete.

Excavation and material segregation would require that three stockpile or staging areas be used: one for the cover material, one for the waste, and one for the backfill and alluvium. The waste material would be loaded onto plastic-lined trucks and transported off-site to a permitted incineration and landfill facility. The backfill and alluvium would undergo stabilization. The cover material would be replaced back into the excavation once the stabilization process is complete and all

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stabilized materials have been returned to the excavation. (The cover material would be uncontaminated or contains contaminants at levels below the action level.)

The area covering and adjacent to the Inactive Site would be regraded to divert storm water run-on and enhance storm water run-off. The Inactive Site ponds are located on a topographic high; therefore, flow would be diverted into the East Branch of Brush Creek drainage for flow to the north and into the West Branch of Brush Creek/Dry Gulch drainage for flow to the south.

A multi-layered cap is proposed for covering the Inactive Site area, which includes the five ponds and the area adjacent to the ponds. The cap would be sloped to divert surface flow away from the ponds.

Ground water monitoring would be conducted to monitor contaminant migration.

The cap would be maintained and no construction would occur on or near the cap. Since contaminants would remain at the Inactive Site, the site would be reviewed at least every 5 years by the EPA to assure that human health and the environment are protected. Periodic 5 year reviews at the Chemical Storage Tank area would not be required since the organic contaminants would be removed from the soil.

In-situ soil vapor extraction used to remove VOCs from the Chemical Storage Tank area subsurface soil requires a series of extraction wells connected to a vacuum pump be installed in and around the Chemical Storage Tank area. A series of injection wells connected to a blower or vacuum pump would be placed in and around the Chemical Storage Tank area and used to induce air flow through the soil to strip and volatilize the VOCs into the air stream. Subsurface air, VOC vapors, and water vapors would migrate toward the vacuum extraction wells and be recovered for collection and treatment. Air emissions would be monitored, and additional controls would be incorporated as necessary.

Approximately, 2,100 cy of waste would be transported off-site. Approximately 24,400 cy of contaminated backfill and alluvium would be treated by ex-situ stabilization. The stabilization process incorporates the contaminated soil into a matrix with additives such as Portland cement, water, and proprietary compounds to immobilize the contaminants by chemically and physically binding them in-place. Stabilization is a process that can be performed in an open pit, in concrete trucks, and in fabricated systems designed specifically for stabilization. Both stationary and mobile

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(skid-mounted) systems are available. The specific system and additives would be chosen during the design phase.

MMAG performed bench-scale stabilization and thermal process treatability studies on Inactive Site pond materials. The treatability studies are discussed in Section 8.0.

The removal of the waste from the ponds and stabilization of the contaminated backfill and alluvium would significantly reduce the impact of the Inactive Site on ground water contamination. The installation of a RCRA cap at the Inactive Site would provide added insurance that the potential for direct human contact would be minimized. In-situ soil vapor extraction would effectively remove contaminants from the Chemical Storage Tank area. Contaminated soil materials would remain on-site but the constituents would be less mobile.

The uncertainties associated with Alternative S-3 are the ability to lower the ground water table enough to avoid intersecting the ponds. However, reducing infiltration via a cap and in turn lowering the ground water table will be effective to some extent. Another uncertainty is the ability to stabilize organic contaminants. During the stabilization operation, the contaminated soils would be handled several times. First the soil would be excavated, and then stockpiled. It would then undergo size reduction, and then proceed through the stabilization process, which often undergoes several temperature fluctuations due to ambient air temperatures, process water temperatures, and chemical reactions. With each of these activities, some volatilization is likely to occur.

The transport of waste would comply with RCRA, Department of Transportation, and State regulations. Incineration of the waste would be performed at a RCRA-permitted incineration facility and would meet all requirements including at least a 99.99 percent destruction of organic contaminants. Disposal of the treated waste would comply with RCRA standards, including the LDRs. Stabilization treatment goals would be based upon LDR standards using the Toxicity Characteristic Leaching Procedure (TCLP). Perched water and wastewaters generated from the treatment processes on-site would be treated and discharged according to MMAG's COPDES permit requirements. All activities, including in-situ soil vapor extraction, would comply with ambient air quality standards.

Implementation of the Alternative S-3 is estimated to take 18 months.

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**6.4 ALTERNATIVE S-4: DEWATER/ON-SITE INCINERATION OF BACKFILL, ALLUVIUM, AND WASTE/OFF-SITE DISPOSAL OF INCINERATED RESIDUES/ EX-SITU STABILIZATION OF INCINERATED BACKFILL AND ALLUVIUM/RCRA CAP/IN-SITU SOIL VAPOR EXTRACTION**

The objective of this alternative is to provide long term protection of the ground water and human health by removing and treating waste at the Inactive Site Ponds. By destroying the organic contaminants and stabilizing the inorganic contaminants, additional contaminant loading on the ground water is precluded and potential human exposure is effectively eliminated.

Alternative S-4 incorporates dewatering of the Inactive ponds, excavation and on-site incineration of waste, backfill, and alluvium from the Inactive Site ponds, off-site disposal of the incinerated waste in accordance with LDRs, ex-situ stabilization of the backfill and alluvium, replacement of waste into the excavation, placement of cover material into the excavation, and placement of a cap over the Inactive Site. In-situ soil vapor extraction would be used for contaminated soil at the Chemical Storage Tank area.

Alternative S-4 would be implemented in 3.5 to 4 years.

Dewatering would be implemented as described previously. Controls to collect vapors with integrated vacuum systems during excavation will be evaluated during the design phase.

Since excavation would be required for this alternative and the waste would be disposed of separately at an off-site RCRA landfill, material segregation would be necessary at the Inactive Site. It is anticipated that three stockpile or staging areas would be necessary. The waste material would be incinerated in the on-site incinerator, allowed to cool, then loaded onto plastic-lined trucks and transported to an off-site landfill. The backfill and alluvium would then be incinerated after excavation, processed through stabilization and returned to the excavation. The cover material would be replaced back into the excavation once the stabilization process was complete and all stabilized materials would be returned to the excavation.

The area covering and adjacent to the Inactive Site would be regraded and capped as described previously in the other alternatives.

Ground water monitoring would be conducted to monitor contaminant migration.

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The cap would be maintained and construction restricted on or near the cap. Since contaminants would remain at the Inactive Site, the site would be monitored and every five years a review would be conducted to assure that human health and the environment are protected.

As described earlier, in-situ soil vapor extraction would be used to remove VOCs from the Chemical Storage Tank area subsurface soil.

Because the waste in the Inactive Site ponds is considered a RCRA Listed Hazardous Waste, the waste must be treated to meet the treatment standards established for RCRA Listed Waste, particularly F001, F005, and F019. The best demonstrated available technology (BDAT) for the F001 and F005 waste is incineration. The BDAT for F019 waste is stabilization. The waste, approximately 2,100 cy, would be incinerated on-site. The residues would be allowed to cool, loaded onto lined trucks and transported to an off-site landfill. The Inactive Site contains low levels of the F019 or inorganic contaminants. If the incinerated waste residues did not satisfy the LDR treatment standards for F019 (inorganic) wastes, they would be stabilized prior to land disposal in a RCRA Landfill. The incineration residue would be transported to a landfill for stabilization to avoid transporting the additional 10 to 40 percent volume that would be generated if stabilization was performed on-site.

The contaminated backfill and alluvium would be incinerated on-site after all waste was removed and treated. A rotary kiln process is proposed for incineration. Rotary kiln incinerators are the most widespread, most proven, and most readily available of the incineration processes; however, other types of incinerators would be considered during the design phase.

Following on-site incineration, approximately 24,400 cy of backfill and alluvium would be treated by ex-situ stabilization in order to immobilize inorganic contaminants. The stabilization process incorporates the contaminated soil into a matrix with additives such as Portland cement, water, and proprietary compounds to immobilize the contaminants by chemically and physically binding them in-place.

Stabilization can be performed in an open pit, in concrete trucks, and in fabricated systems designed specifically for stabilization. Both stationary and mobile systems are available. The specific system and additives to be used will be determined during the design phase. The stabilized product would either be replaced directly back into the excavation or placed in forms and allowed to cure before being placed into the excavation.

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**MMAG conducted bench-scale treatability studies on thermal treatment and stabilization of Inactive Site Pond materials. The results of the treatability studies are discussed in Section 8.0.**

**The removal of the waste from the ponds and incineration and stabilization of the contaminated backfill and alluvium would significantly reduce the impact that the Inactive Site has on ground water contamination. The installation of a cap at the Inactive Site would provide added assurance that the potential for direct human contact would be minimized. In-situ soil vapor extraction would effectively remove contaminants from the Chemical Storage Tank area, so there would be no concern for exposure. Contaminated materials would remain on-site but the constituents would be immobilized.**

**Incineration of the waste, backfill, and alluvium would comply with or exceed the technical requirements of RCRA and the Toxic Substances Control Act (TSCA). The hazardous waste incineration standards set forth in 40 CFR Parts 264 and 270 specify three major requirements regarding incinerator performance:**

- 1. Principal organic hazardous constituents (POHCs) designated in each waste feed must be destroyed and/or removed to an efficiency (DRE) of 99.99 percent or better; the DRE for dioxins and PCBs must be 99.9999 percent.**
- 2. Particulate emissions must not exceed 180 milligrams per dry standard cubic meter (dscm) corrected to 7 percent oxygen in the stack gas.**
- 3. Gaseous hydrogen chloride (HCl) emissions must either be controlled to 4 pounds/hour or less, or be removed with 99 percent efficiency.**

**The transport of Inactive Site pond waste would comply with RCRA, Department of Transportation, and State regulations. Disposal of the treated waste would comply with RCRA standards, including LDRs. Stabilization would achieve immobilization such that contaminants meet the treatment standards. Perched water and wastewaters generated from the treatment processes on-site would be treated to meet COPDES permit requirements. All activities, including in-situ soil vapor extraction, would comply with ambient air quality standards. This alternative satisfies the SARA preference for treatment.**

**6.5 ALTERNATIVE S-5: DEWATER/OFF-SITE INCINERATION AND DISPOSAL OF WASTE/THERMAL EXTRACTION OF BACKFILL AND ALLUVIUM/EX-SITU STABILIZATION OF BACKFILL AND ALLUVIUM/RCRA CAP/VAPOR IN-SITU SOIL VAPOR EXTRACTION**

The objectives of Alternative S-5 are to prevent the further impact from the Inactive Site area on ground water and minimize the potential for direct human contact with, inhalation of, and ingestion of contaminants at both areas. This alternative is designed to remove organic contaminants and immobilize inorganic contaminants at the Inactive Site, reduce infiltration of precipitation through the Inactive Site pond, and remove organic contaminants from the Chemical Storage Tank area.

Alternative S-5 incorporates dewatering of the Inactive Site ponds; excavation, off-site incineration and disposal of waste in accordance with LDRs; excavation, thermal extraction and, stabilization of contaminated backfill and alluvium; replacement of treated backfill and alluvium into the excavation; and capping over the Inactive Site. In-situ soil vapor extraction would be used to treat the soil at the Chemical Storage Tank area. In addition, this alternative includes the off-site incineration and disposal of the residual organic laden sludge from the thermal extraction process and the off-site incineration and disposal of regeneration of the carbon from the in-situ soil vapor extraction process and the thermal extraction air treatment system.

Alternative S-5 would be implemented in 4 years.

The area covering and adjacent to the Inactive Site would be regraded to divert storm water run-on and enhance storm water run-off. Grading would be accomplished using conventional construction equipment such as front-end loaders and grade-alls. Water trucks would be used to minimize dust generation. The Inactive Site ponds are located on a topographic high; therefore, flow would be diverted into the East Branch of Brush Creek drainage for flow to the north and into the West Branch of Brush Creek/Dry Gulch drainage for flow to the south.

Ground water monitoring would be conducted at both the Inactive Site and the Chemical Storage Tank area to monitor contaminant migration from both areas. Monitoring wells would be placed within the perched zones to verify that infiltration was the source of the perched water and that the perched zones were not being recharged. The monitoring wells in the Chemical Storage Tank area would be placed such that the effectiveness of in-situ soil vapor extraction could be monitored.

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The cap would be maintained and no construction would occur on or near the cap. Since low levels of contaminants would remain at the Inactive Site, the site would be monitored and every 5 years a review would be conducted to assure human health and the environment are protected.

In-situ soil vapor extraction would be used to remove VOCs from the Chemical Storage Tank area subsurface soil. A series of extraction wells connected to a vacuum pump would be installed in and around the Chemical Storage Tank area such that the cones of influence would extend over the entire contaminated area. A series of injection wells connected to a blower or vacuum pump would be placed in and around the Chemical Storage Tank area and used to induce air flow through the soil to strip and volatilize the VOCs into the air stream. Subsurface air, VOC vapors, and water vapors would migrate toward the vacuum extraction wells in response to the negative pressure gradient around the well.

The contaminated air and vapor would flow to a vapor/liquid separator where contaminated water would be removed. The contaminated water would be treated to meet COPDES limits in MMAG's IWTP. The contaminated air stream would be treated to remove VOC concentrations to air quality standards. The carbon would be either regenerated or disposed of accordingly. Air emissions would be monitored and additional controls would be incorporated as necessary.

The waste in the Inactive Site ponds is considered a RCRA Listed Hazardous Waste. The waste, approximately 2,100 cy, would be loaded onto lined trucks and transported to an off-site incinerator permitted to accept F001, F005, and F019 listed wastes. The waste would be incinerated to comply with the F001 and F005 LDR treatment standards. If the incinerated waste residues did not satisfy the LDR treatment standards for F019 (inorganic) wastes, they would be stabilized prior to land disposal in a RCRA Landfill.

Approximately 24,400 cy of contaminated backfill and alluvium would be treated by thermal extraction to remove organic contaminants. Thermal extraction is a low temperature thermal treatment process which volatilizes organic contaminants from the soil matrix. Operating temperatures are low, preventing combustion of the organic contaminants and oxidation of the inorganic contaminants. The process produces an organic-free soil and an off-gas that, when treated, generates waste water, clean air, and an organically contaminated sludge.

Following the thermal treatment, approximately 24,400 cy of backfill and alluvium would be treated by ex-situ stabilization. The stabilization process incorporates the contaminated soil into a

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matrix with additives such as Portland cement, water, and proprietary compounds to immobilize the inorganic contaminants by chemically and physically binding them in-place.

Treatability studies on thermal extraction and stabilization were performed previously by MMAG. The results are discussed in Section 8.0.

The removal and incineration of the waste from the ponds and thermal extraction and stabilization of the contaminated backfill and alluvium would significantly reduce the impact that the Inactive Site has on ground water contamination. The installation of a multi-layered cap at the Inactive Site would provide added assurance that the potential for direct human contact would be minimized. In-situ soil vapor extraction would effectively remove contaminants from the Chemical Storage Tank area so there would be no concern for exposure. Contaminated materials would remain on-site would be treated to immobilize hazardous constituents.

The uncertainty associated with Alternative S-5 is the ability to remove organic contaminants and stabilize inorganic compounds to meet LDR treatment standards.

The transport of Inactive Site pond waste and thermal extraction residues would comply with RCRA, Department of Transportation, and State regulations. Incineration of the waste would be performed at a RCRA approved incineration facility and would meet all pertinent requirements including at least a 99.99 percent destruction of organic contaminants. Disposal of the treated waste would comply with RCRA standards, including the LDRs. Thermal extraction would remove organic contaminants, and stabilization would achieve immobilization to prevent contaminants from leaching to the ground water. Perched water and wastewaters generated from the treatment processes on-site would be treated to meet MMAG's COPDES permit requirements. All activities, including thermal extraction and in-situ soil vapor extraction, would comply with ambient air quality standards.

## **6.6 ALTERNATIVE GW-1: NO ACTION**

In accordance with Section 300.430(e)(6) of the NCP, the no action alternative must be considered in the FS. The no action alternative also serves as a baseline for comparison of other ground water alternatives. No contaminants are removed or treated by the no action alternative, although natural attenuation processes are likely to occur. Predicting natural attenuation processes is not technologically possible for most of the contaminants present in the ground water.

No action, as it pertains to ground water contamination, means that no activities intended to protect human health and the environment, including any remediation, would be taken. The existing Brush Creek and Filter Gulch ground water extraction and treatment systems would be shut down. The existing water supply provided by the Denver Water Department could be used to meet current water demands and future demands from development. Contaminated ground water would be allowed to migrate off-site.

Ground water monitoring would be conducted to track contaminant migration from the site and to continually assess the resulting risks.

Ground water modeling, assuming the source is removed and natural attenuation processes occur, predicts that ground water restoration time frames required to attain clean up goals are in excess of 130 years for on-site ground water and in excess of 70 years for off-site ground water.

This alternative does not provide protection against threats to human health or the environment. The immediate concern with the no action alternative is that environmental degradation would continue to occur and that the remedial action objective to restore ground water to its beneficial use in a reasonable time frame is not achieved.

The ground water, which is a past and a potential source of drinking water, does not meet the clean up goals at the present time.

**6.7 ALTERNATIVE GW-2: CONTINUED OPERATION OF THE EXISTING RECOVERY WELL SYSTEMS/TREATMENT BY AIR STRIPPING, CARBON ADSORPTION, AND ION EXCHANGE/DISCHARGE TO BRUSH CREEK**

The objectives of Alternative GW-2 would be to preclude ground water migration off-site into the South Platte River Basin and remove organic and inorganic contaminants from the recovered ground water.

Alternative GW-2 is presently in operation. The Filter Gulch recovery well system was installed in 1985, and the Lower Brush Creek recovery system was installed in 1987. The Filter Gulch recovery system consists of 14 recovery wells located approximately 800 feet southeast of the M3 area on Denver Water Department property. The Brush Creek recovery system consists of three 24-inch diameter recovery wells installed in a gravel backfilled trench located approximately 2,000 feet east of the M3 area.

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The recovered water is pumped along with MMAG's industrial process waste waters to the IWTP in the M3 area where organic and inorganic contaminants are removed. Currently, the IWTP treats wastewater by air stripping, carbon adsorption, and a ferrous sulfate reduction processes. The treated effluent is discharged to Brush Creek MMAG waste water outfall (COPDES Permit #0001511), located approximately 100 feet downstream of the Brush Creek recovery system.

Ground water monitoring would be conducted semiannually to track contaminant migration from the site and to assess the resulting risks.

An alternative water supply would be provided should the need arise during the implementation of alternative GW-2.

MMAG has demonstrated that the Filter Gulch and Brush Creek recovery systems provide effective containment of contaminants by minimizing off-site migration of alluvial ground water.

The principal environmental concern associated with air stripping is the generation of volatile organic air emissions. The MMAG IWTP is presently operating within its air permit limitations, which do not require additional treatment of the exhaust air stream. If air emission levels are found to exceed ambient air quality standards or risk-based levels, the air would require further treatment. Treatment of the exhaust air would be accomplished by capturing organic constituents using vapor phase carbon adsorption or by destruction in an incinerator. The need for emission controls would be assessed during the design phase.

All the residues of ground water treatment would be analyzed for contaminant content and disposed of accordingly. Sludges would most likely be incinerated at an off-site facility prior to disposal. Spent carbon and ion exchange resins would either be recycled (regenerated), incinerated, and/or disposed of directly.

The treated effluent exiting the MMAG IWTP would meet the required treatment standards of MMAG's COPDES permit before being discharged to Brush Creek via the existing outfall.

Ground water modeling indicates that ground water restoration time frames required to attain clean up goals are approximately 130 years for on-site ground water and in excess of 5 years for off-site ground water. However, there is some uncertainty in the estimate of ground water restoration time. The ground water modeling was conducted using available data on subsurface conditions, and assumptions were made regarding all the variables. In addition, the model assume that sources of

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contamination are completely removed. Effectively, this means little if any remediation occurs on-site in the highly contaminated areas for an extensive period.

The untreated ground water does not meet the clean up goals at the present time. With the implementation of alternative GW-2, however, clean up goals would be achieved off-site in a reasonable time frame. However, contaminant levels in ground water on-site would remain above MCLs for over 100 years.

**6.8 ALTERNATIVE GW-3: CONTINUED OPERATION OF THE EXISTING RECOVERY WELL SYSTEMS/INSTALLATION OF ADDITIONAL RECOVERY WELL SYSTEMS IN FILTER GULCH AND DRY GULCH UPGRADIENT FROM THE EXISTING RECOVERY WELL SYSTEMS/TREATMENT BY AIR STRIPPING, CARBON ADSORPTION, ION EXCHANGE, AND/OR UV PHOTOLYSIS- OXIDATION/DISCHARGE TO BRUSH CREEK**

The objectives of Alternative GW-3 would be to preclude contaminant migration off-site and restore the ground water to beneficial uses by recovering ground water and removing organic and inorganic contaminants.

Alternative GW-3 is a modification to Alternative GW-2 that incorporates two additional extraction systems coupled with recharge or infiltration trenches to enhance the rate of ground water extraction. One of the two new recovery systems would be installed in Dry Gulch, approximately 3,500 feet southeast of the Inactive Site, and the other would be installed in Filter Gulch southeast of the M3 area, approximately 200 feet north of the MMAG property boundary. The new recovery system in Dry Gulch would probably consist of a trench and well system similar to the existing Brush Creek system and would recover 5 - 10 gpm. The new system in Filter Gulch would probably consist of a line of recovery wells similar to the existing Filter Gulch system. Additionally a treatment step to remove NDMA and UDMH contamination is included. The additional treatment step associated with this alternative is ultraviolet light (UV) photolysis used in combination with oxidation to treat NDMA and UDMH.

The ground water would be pumped from the four recovery systems and treated at the IWTP. Organic and inorganic contaminants would be removed. The IWTP would include air stripping, carbon adsorption, ion exchange, and the UV photolysis/oxidation process. The treated effluent would be discharged to the Brush Creek MMAG waste water outfall (COPDES Permit #0001511), located approximately 100 feet downstream of the Brush Creek recovery system.

Ground water monitoring would be conducted to track contaminant migration from the site and to assess the resulting risks. An alternate water supply would be provided should the need arise during the implementation of alternative GW-3.

Water purchased from the Denver Water Department would be recharged into the alluvium at Dry Gulch and the M3 area to enhance extraction rates and flushing of the alluvium for more rapid restoration.

It could also be necessary to install a small extraction system upgradient of the Inactive Site recharge system to collect ground water located between the ponds and the recharge system. The need for such a system would be evaluated during the design phase.

Ground water modeling indicates that ground water restoration time frames required to attain clean up goals are approximately 45 years for on-site ground water and approximately 5 years for off-site ground water.

The untreated ground water does not meet the clean up goals at the present time. With the implementation of alternative GW-3, however, clean up goals would be achieved more rapidly both off-site and on-site.

**6.9 ALTERNATIVE GW-4: CONTINUED OPERATION OF EXISTING RECOVERY WELL SYSTEMS/INSTALLATION OF ADDITIONAL RECOVERY WELL SYSTEMS IN FILTER GULCH AND DRY GULCH UPGRADIENT FROM THE EXISTING RECOVERY WELL SYSTEMS/ADDITION OF A RECOVERY WELL SYSTEM IN THE M3 AREA/TREATMENT BY CHEMICAL REDUCTION, PRECIPITATION, CLARIFICATION, AIR STRIPPING, CARBON ADSORPTION, ION EXCHANGE, AND/OR UV PHOTOLYSIS-OXIDATION/DISCHARGE TO BRUSH CREEK**

The objectives of Alternative GW-4 are to preclude contaminant migration off-site and restore the ground water to beneficial uses by recovering ground water and removing organic and inorganic contaminants from the ground water. Additionally, this includes systems to collect and treat the ground water in the Fountain Formation in the vicinity of the Chem Mill and Hydrostat Tank areas.

This alternative provides protection to human health and the environment by removing contaminants in the ground water and by reducing contaminant migration off-site.

Alternative GW-4 is a modification of alternative GW-3. It incorporates all the aspects of GW-4 and in addition includes one more extraction system. The water extracted by the additional

system would be treated to remove chromium and chlorinated organic compounds. The water would be recovered from the five systems and pumped to the IWTP where organic and inorganic contaminants would be removed. The IWTP would include air stripping, carbon adsorption, ion exchange, and the addition of the UV photolysis/oxidation and chemical reduction, precipitation, and clarification processes. The treated effluent would be discharged to the Brush Creek MMAG waste water outfall (COPDES Permit #0001511), located approximately 100 feet downstream of the Brush Creek recovery system.

Ground water monitoring would be conducted to track contaminant migration from the site and to assess the resulting risks. An alternate water supply would be provided should the need arise during the implementation of alternative GW-3.

Ground water modelling indicates that ground water restoration time frames required to attain clean up goals are approximately 45 years for on-site ground water and in excess of 5 years for off-site ground water. However, there is some uncertainty associated with the ground water restoration time. The ground water modeling was conducted using available data on subsurface conditions, and assumptions were made regarding all the variables. In addition, the model assumes that sources of contamination are completely removed.

The untreated ground water does not meet the clean up goals at the present time. With the implementation of Alternative GW-4, however, these goals would be achieved on-site and off-site within reasonable time frames. In addition, an area of high contamination in the M3 area would be remediated preventing further migration of contaminants off-site.

## **7.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES**

### **7.1 INTRODUCTION**

In accordance with the NCP, Section 300.430(e), each of the alternatives passing the initial screening phase of the feasibility study underwent the detailed analysis which specifically addresses the nine evaluation criteria listed below:

#### **Threshold Criteria**

1. Overall protection of human health and the environment
2. Compliance with applicable or relevant and appropriate requirements (ARARs)

Primary Balancing Criteria

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost

Modifying Criteria

8. State acceptance
9. Community acceptance

The NCP indicates that a remedy must satisfy the threshold criteria to be eligible for selection.

**7.2 COMPARATIVE ANALYSIS OF SOIL ALTERNATIVES**

This section provides a comparison of each of the soil alternatives with respect to the nine evaluation criteria described above. The results of the comparative analysis are summarized in Table 7-1.

**7.2.1 Overall Protection of Human Health and the Environment**

All of the alternative, except no action, would provide some degree of protection to human health and the environment.

Protectiveness is in part related to the final disposition of contaminants, and alternatives S-4 and S-5 employ proven processes to treat all waste and provide for the destruction of organic compounds with treatment and containment of inorganic contaminants. Both alternatives are considered permanent remedies and, therefore provide long-term effectiveness and protection. Alternative S-3 is protective and it includes treatment of all waste, although the organic compounds would not be removed or destroyed and would potentially be able to leach from the stabilized product. Alternative S-2 is protective from the standpoint that the potential for direct human contact is reduced and that infiltration is reduced, thereby reducing the potential for contaminant migration

**TABLE 7-1 SUMMARY OF COMPARATIVE ANALYSIS FOR SOIL ALTERNATIVES**

ALTERNATIVE					
EVALUATION CRITERION	S-1	S-2	S-3	S-4	S-5
Overall Protection of Human Health and the Environment	Not protective.	Provides protection, but does not involve any treatment or removal of contaminated soil or waste at Inactive Site. Potential exists for future human exposure possible if cap is not maintained.	Provides protection, but uncertainty exists regarding ability to stabilize organic contaminants and in turn, long-term protection is uncertain.	Highly protective and organic contaminants would be removed and destroyed. Inorganic contaminants would be immobilized.	Also highly protective. Organic contaminants would be removed and destroyed. Inorganic contaminants would be immobilized. Degree of organic contaminant destruction would be somewhat less than Alternative S-4.
Compliance with ARARs	Not applicable.	Complies with all ARARs.	Complies with all ARARs.	Complies with all ARARs.	Complies with all ARARs.
Long-term Effectiveness and Permanence	Does not offer any long-term effectiveness or permanence.	The RCRA cap would provide a long-term solution for minimizing the mobility of contaminants. Contaminants would remain in-place, untreated, and continue to contaminate ground water. Most organic contamination would be permanently removed from the Chemical Storage Tank area. Ground water restoration would be less certain because the contaminant source would not be totally controlled/removed.	All contaminants would be treated, however, the effectiveness of organic contaminant stabilization is uncertain. The RCRA cap would decrease the mobility of contaminants. Most organic contamination in the Chemical Storage Tank area would be permanently removed. Inorganic and organic contaminants would remain in-place at the Inactive Site, but would be stabilized.	Provides the most effective and permanent remedy. Organic contaminants would be removed from the site and destroyed. Inorganic contaminants would be immobilized. Perched water would be permanently removed and treated. The RCRA cap would minimize the mobility of residual contaminants.	Provides a highly effective and permanent remedy. Organic contaminants would be removed from the site and destroyed. Inorganic contaminants would be immobilized. Perched water would be permanently removed and treated. The RCRA cap would minimize the mobility of contaminants.

TABLE 7-1 (Continued)

ALTERNATIVE					
EVALUATION CRITERIA	S-1	S-2	S-3	S-4	S-5
Reduction of Toxicity, Mobility, or Volume Through Treatment	None	Removes and destroys 95-99 percent of the VOCs from the Chemical Storage Tank area. Cap would reduce mobility of contaminants at the inactive Site.	Potentially immobilizes inorganic and organic contaminants at the inactive Site (24,400 cy). Removes and destroys 99.99 percent of the organic contaminants in the waste. Removes and destroys 95-99 percent of the VOCs from the Chemical Storage Tank area. Treated soil would be capped to reduce mobility of residual contaminants at the inactive Site. Volume increases are possible with stabilization.	Removes and destroys up to 99.99 percent of the organic contaminants in the waste and in the soil at the inactive Site (2,100 cy of waste and 24,400 cy of backfill and alluvium). Immobilizes inorganic contaminants at the inactive Site (24,400 cy). Removes and destroys 95-99 percent of the VOCs from the Chemical Storage Tank area. Treated waste would be landfilled. Treated soil would be capped to reduce mobility of residual contaminants at the inactive Site. Residues of thermal treatment require further treatment.	Removes and destroys up to 99.99 percent of the organic contaminants in the waste and 99 percent of the organic contaminants in the soil at the inactive Site (2,100 cy of waste and 24,400 cy of backfill and alluvium). Immobilizes inorganic contaminants at the inactive Site (24,400 cy). Reduces the volume of waste to be treated offsite. Removes and destroys 95-99 percent of the VOCs from the Chemical Storage Tank area. Treated waste would be landfilled. Treated soil would be capped to reduce the mobility of residual contaminants at the inactive Site. Residues of thermal extraction require further treatment by off-site incineration.
Short-term Effectiveness	No action would be taken therefore, natural attenuation processes would take in excess of 200 years to meet cleanup goals. Alternative S-1 is not effective in the short-term. Contaminant migration would continue unrestricted. However, no exposure to humans occurs under present conditions.	This alternative is for the short-term because remediation activities require no contact with contaminants at the inactive Site and the remedy is quickly implemented in relation to others. Potential for inhalation of vapors would be low. Minimal risk associated with well installations and operation of vapor and water extraction systems. Requires the shortest implementation time (4 months) of all alternatives, excluding no action.	Implementation involves off-site incineration and on-site stabilization, both of which will generate airborne emissions that must be controlled. There would be a potential for dermal contact with, inhalation of, and ingestion of contaminants. This alternative would be the second most effective alternative for the short-term because on-site treatment would be limited to stabilization and vapor extraction.	The least effective alternative for the short-term because of the use of on-site incineration for the destruction of organic contaminants in the waste and soil. Air emissions from the incinerator would require stringent air pollution controls. A trial burn would be required to demonstrate that emissions would be effectively controlled. Other processes would present minimal risks. Stabilization would pose no significant risk since VOCs would have been removed by incineration. Incineration would require longer implementation than other alternatives.	Slightly higher effectiveness rating than Alternative S-4; because thermal extraction emissions would be controlled more easily than incineration emissions. Other processes would present minimal risks. Stabilization would pose no significant risk since the VOCs would have been removed by thermal extraction. Shorter time would be required to implement this alternative compared to S-4. Health threats to the public are not expected, however, for either S-4 or S-5.

TABLE 7-1 (Continued)

ALTERNATIVE					
EVALUATION CRITERIA	Implementability	Cost Capital O&M Present Worth	State Acceptance	Community Acceptance	
S-1	Technically sound, implementation of the no action alternative would pose no problems. Implementation of no action would be accomplished in less than 1 year.	\$0 \$39,000 \$600,000	Unacceptable.	No comments received. As-	No comments received. As-
S-2	Implementation would be accomplished using readily available materials, conventional equipment, and labor. Implementation would be achieved in 4 months. The administrative requirements would be easily accomplished.	\$2,823,000 \$131,500 \$4,940,000	Least acceptable excluding S-1.	No comments received. As-	No comments received. As-
J	Implementation would be accomplished using readily available materials, conventional equipment, and labor in 18 months. The administrative requirements would be easily accomplished.	\$21,723,000 \$131,500 \$23,740,000	Least acceptable excluding S-1.	No comments received. As-	No comments received. As-
S-4	Implementation would be accomplished using either a vendor supplied mobile unit or fabricated on-site unit. Other procedures would be implemented using readily available materials, conventional equipment, and labor. Approximately 3.5 - 4 years would be required to implement. The administrative requirements would be most complicated to implement of all the alternatives.	\$45,823,000 \$131,500 \$47,840,000	Acceptable to the State, depending on the incinerator design.	No comments received. As-	No comments received. As-
S-5	Implementation of Alternative S-5 would require the use of either a vendor supplied or on-site fabricated thermal extraction unit. Other procedures would be implemented using readily available materials, conventional equipment, and labor. Approximately 4 years would be required to implement. The administrative requirements are relatively easy to accomplish. Thermal extraction equipment is less available than other technologies.	\$39,023,000 \$131,500 \$41,040,000	Acceptable to the State. State concurs with S-5 as selected remedy.	No comments received. As-	No comments received. As-

into the ground water. Alternative S-2, however, does not address the existing contaminated alluvium which is and will continue to be intersected by ground water and it is not necessarily a permanent solution. Each of these alternatives also reduce mobility of contaminants remaining in the soils due to the placement of a RCRA cap over contaminated or treated areas to minimize infiltration of precipitation.

Alternative S-1 does not provide any protection to human health and the environment. At present, neither the Inactive Site soils nor the Chemical Storage Tank area soils present a threat to the MMAG employees or trespassers because both areas are covered. The Inactive Site is covered by soil and the Chemical Storage Tank area by asphalt. However, contaminants in the soil that migrate from both areas and enter the ground water could result in exposure to contaminants causing threats to human health and the environment.

#### **7.2.2 Compliance with ARARs**

Chemical-, location-, and action-specific ARARs were identified for the MMAG site and the alternatives developed. The full ARARs analysis is presented in Appendix A of the feasibility study (Geraghty & Miller, 1990b). Each alternative would comply with ARARs. The number of ARARs that apply to an alternative increases with the amount of treatment involved.

#### **7.2.3 Long-term Effectiveness and Permanence**

Alternatives S-4 and S-5 would provide the highest degree of long-term effectiveness and would also be the most permanent remedies primarily because both alternatives would use treatment to remove and destroy organic contaminants at the Inactive Site. Alternative S-4 would use direct destruction via incineration, whereas Alternative S-5 would use removal via thermal extraction followed by destruction via incineration off-site. For Alternatives S-3, S-4, and S-5, the inorganic contaminants would be immobilized by stabilization. The long-term effectiveness of stabilization would, in part, depend on the ability of the RCRA cap to minimize infiltration through the solidified mass. RCRA caps have been used extensively and have been shown to be effective, long-term solutions for reducing infiltration. The RCRA cap would require periodic maintenance that consists of sealing cracks, adjusting for settlement, and revegetating. With proper maintenance and design, the cap would function effectively and last indefinitely.

Alternative S-3 would be the next most effective and permanent alternative, but because organic contaminants remain in place using a technology that has not been proven for organic



contaminants, some questions remain regarding long-term effectiveness. Alternative S-2 would be the next most effective and permanent alternative. However, contamination would remain in the ground untreated and continue to migrate in the environment. Alternative S-1 does not offer any long-term effectiveness or permanence.

Alternatives S-3, S-4, and S-5 would enhance ground water restoration because contamination presently in the saturated alluvium would be treated, and the organic constituents would be removed as part of Alternatives S-4 and S-5.

Alternatives S-2 through S-5 apply in-situ soil vapor extraction at the Chemical Storage Tank area to remove most of the organic contaminants from the soil, thus providing for long-term effectiveness and permanence. (Although capping is not planned for this area, a cap to prevent infiltration would be effective at protecting the environment and preventing human exposure.)

#### **7.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment**

Alternatives S-1 does not involve any treatment of the waste, contaminated backfill, contaminated alluvium at the Inactive Site, or contaminated soil at the Chemical Storage Tank area and therefore does not meet this criterion.

Alternatives S-2 through S-5 all provide some level of reduction in toxicity, mobility, and volume of contaminants. In all of these alternatives, contaminants in the Chemical storage Tank area are removed from the soils thereby reducing the toxicity of the soils and eliminating the potential for further migration of contaminants to the ground water.

This criterion is addressed to the highest degree by alternatives S-3, S-4, and S-5 because these alternatives involve a high level of treatment for contaminants at the Inactive Site area. Incineration of waste materials in alternatives S-3, S-4, and S-5 effectively reduces toxicity, mobility, and volume of contaminants by permanent destruction. Thermal extraction in alternative S-5 accomplishes the same result but by a different mechanism. Volume reduction is a key aspect of S-5 because the thermal extraction process concentrates organic contaminants in a sludge and reduces the volume of material that must be incinerated. A major difference between S-3, S-4 and S-5 is the quantity and type of material which would be thermally treated under each alternative.

The thermal treatment aspect of alternatives S-3, S-4 and S-5 all result in the generation of small quantities of residues. These residual waste streams are the result of air pollution control

devices and may be liquid or solid in form. These residues constitute of small volume of wastes which must be disposed or further treated. Examples of these waste materials are scrubbing liquids (waste water), spent activated carbon, dry scrubbing residues (salts) and ash.

The stabilization treatment portion of alternatives S-3, S-4, and S-5 will reduce mobility of contaminants in the soils. The effectiveness of stabilization varies with the type of contaminant being treated. Only inorganic constituents would be treated by stabilization with S-4 and S-5. However, alternative S-3 would utilize stabilization for immobilizing both inorganic and organic constituents. The use of stabilization to treat organic contaminants is not as well accepted as for inorganic contaminants.

Stabilization treatment would probably result in a volume increase of treated materials due to the addition of stabilizing or solidifying agents. However, depending on the nature of the material being treated and the additives used, volume reduction is also a possibility.

In summary, the treatment aspects of S-4 and S-5 alternatives would provide the highest reductions in toxicity and mobility. Alternative S-1 provides no reductions and S-2 provides less reduction in toxicity and mobility than S-4 and S-5. This is because thermal treatment is proposed for only the discrete waste materials which comprise a small fraction of the contaminated materials at the Inactive Site.

#### 7.2.5 Short-term Effectiveness

The short-term effectiveness of Alternative S-1 with respect to protecting the environment would be very low, primarily because contaminants would continue to migrate into the ground water and significantly increase the time required for ground water restoration. However, there would not be an immediate threat to human health due to the lack of current exposure to contaminants in the ground water and at the Inactive Site.

Alternative S-2 would be most effective for the short-term because implementation of the alternative would take four months and no excavation of contaminated soil or waste would be required. Therefore, risk from inhalation of vapors, inadvertent ingestion of soil, and dermal contact associated with the Inactive Site would be insignificant. The cap would immediately stop infiltration of precipitative and reduce contaminant migration to the ground water and slow subsequent off-site migration.

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Alternative S-3 would be a somewhat less alternative for the short-term. Alternative S-5 would follow Alternative S-3 and Alternative S-4 would be the least effective alternative in the short-term with respect to protecting the environment. All three alternatives have similar components with corresponding short term risks. The risks associated with dewatering and in-situ soil vapor extraction would be the same as described for Alternative S-2. In addition, because excavation of contaminated waste, backfill, and alluvium would be required, there are short term risks associated with inhalation of, ingestion of, and dermal contact with contaminants for on-site workers. These risks can be controlled by the use of safe working practices and engineering controls during implementation.

Off-site incineration of the waste (Alternatives S-3 and S-5 only) would pose some risk to the community as a result of the transport of hazardous waste on public roads and highways. The loading and unloading procedure may expose workers to contaminants. These risks would be controlled by establishing procedures for safe transfer of waste materials and careful planning of transportation. In the event of an accident, waste material would be cleaned up in a relatively short time (several hours) and community exposure is unlikely.

The transport of treated waste residuals would be required for Alternative S-4 and S-5. However, the risks would be significantly less with S-4 because the materials being transported would be free of organic contaminants.

During S-3 stabilization treatment would result in a risk to workers from inhalation of vapors. Inadvertent ingestion or dermal contact with soil is a risk for all three alternatives S-3, S-4, and S-5. This risk would be greater for Alternative S-3 because organic contaminants would still be present during stabilization.

In summary, the short term effectiveness of alternative S-2 is the greatest because it provides a relatively quick solution for remediation and the human health risks associated with implementing the remedy are less than S-3, S-4 and S-5. Alternative S-1 provides no short term protection to the environment, however, S-1 poses no threat to human health associated with implementation.

#### **7.2.6 Implementability**

Implementability refers to the technical and administrative feasibility of implementing an alternative and the availability of service and material. All the alternatives would be technically implementable. Conventional construction equipment would be used for excavation, transport, and

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replacement. On-site treatment processes would be vendor supplied or designed and fabricated by MMAG. Off-site incineration and disposal would be performed at permitted facilities. All the technologies involved in the alternatives are reliable. Incineration and stabilization have been used extensively to treat hazardous waste and are considered the BDATs for organic and inorganic contaminants, respectively. Thermal extraction is a relatively innovative technology that operates on proven thermodynamic properties. A RCRA cap is considered the best demonstrated available technology (BDAT) for cover types and has been used extensively and successfully at hazardous waste sites and landfills. In-situ soil vapor extraction is a relatively new technology adapted from the proven air stripping technology for removing VOCs from aqueous streams. Carbon adsorption is proven technology widely used in waste water and water treatment plants as well as hazardous waste sites for removing organic contaminants from aqueous waste streams.

Alternative S-5 has the disadvantage of utilizing a thermal treatment technology that is not as readily available as conventional incineration. Thermal extraction is relatively new technology and although there are several companies offering the technology, they are fewer in number than incineration vendors.

The administrative feasibility of alternatives varies from alternative to alternative. Alternative S-2 could be implemented with little administrative or technical difficulty. The only administrative requirements to be achieved would be to meet ambient air quality standards for the in-situ vapor extraction process. Alternative S-2 would be readily adaptable if additional remedial actions were necessary at a later date. Alternatives S-3 and S-5 would be relatively simple to implement from a regulatory stand point. The regulatory requirements for on-site treatment are easily implementable. The off-site treatment and disposal requires very little administrative efforts because the materials would be treated at permitted hazardous waste TSD facilities.

Alternative S-4 would meet with the most difficult alternative to implement on-site due to the regulatory requirements for incineration, such as trial burns.

#### 7.2.7 Cost

MMAG estimated capital, O&M, and present worth costs for each alternative. The costs are presented below:

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<u>Alternative</u>	<u>Capital</u>	<u>O&amp;M</u>	<u>Present Worth</u>
S-1	\$0	\$39,000	\$ 600,000
S-2	\$ 2,923,000	\$131,500	\$ 4,940,000
S-3	\$21,723,000	\$131,500	\$23,740,000
S-4	\$45,923,000	\$131,500	\$47,940,000
S-5	\$39,023,000	\$131,500	\$40,040,000

MMAG also conducted a cost sensitivity analysis to evaluate how the costs respond to fluctuations in various factors such as volumes, interest rates, and unit costs. The results of the sensitivity analysis are summarized below.

SENSITIVITY ANALYSIS OF PRESENT WORTH COSTS

<u>Alternative</u>	<u>Low Cost</u>	<u>High Cost</u>
S-1	\$ 260,000	\$ 980,000
S-2	\$ 2,950,000	\$ 7,180,000
S-3	\$10,150,000	\$ 40,380,000
S-4	\$16,650,000	\$107,480,000
S-5	\$17,150,000	\$ 69,080,000

As indicated in the table above, significant uncertainty exists regarding the cost of Alternative S-4. The low end cost is 35 percent of the estimated present worth cost and the high end cost is 224 percent more than the estimated present worth cost. The uncertainty associated with costs for the other alternatives is not as great.

**7.2.8 State Acceptance**

The no action alternative is not acceptable to the State of Colorado (CDH). CDH prefers alternatives requiring treatment over alternative S-2 and has indicated concurrence with EPA on the selected remedy.

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### **7.2.9 Community Acceptance**

Community acceptance of the soil alternatives is assumed to be in concurrence with the State and EPA. No significant comment regarding the soil alternatives was received during the public meeting or during comment period on the proposed plan.

## **7.3 COMPARATIVE ANALYSIS OF GROUND WATER ALTERNATIVES**

This section provides a comparison of each of the ground water alternatives with respect to the nine evaluation criteria described in Section 7.1. The results of the comparative analysis are summarized in Table 7-2.

### **7.3.1 Overall Protection of Human Health and the Environment**

Each alternative except no action provides some protection of human health and the environment. The ground water alternatives were developed and evaluated based on the assumption that the two major source areas of contamination would be removed. These sources are the contaminants at the Inactive Site and Chemical Storage Tank areas.

Alternative GW-1 would be a step backwards if it were to be implemented. The existing recovery well systems would be shut down and contamination would migrate unrestricted off-site. The long-term impacts would be considerable as the contaminated ground water would contaminate clean ground water and water users distant from the site could be affected. Alternative GW-1 is not protective of either human health or the environment.

MMAG is presently implementing Alternative GW-2. MMAG has been able to demonstrate that this recovery well systems is effective at collecting and treating alluvial ground water. The recovery well systems used to extract ground water are conventional and proven. The treatment processes used are also conventional and widely used to treat municipal water supplies. (The current treatment process for ground water includes only air stripping.)

Alternative GW-3 is protective for the same reasons as GW-2 and is possibly more protective because it reduces the restoration time frame and provides for the treatment of two important contaminants, NDMA and UDMH.

**TABLE 7-2. SUMMARY OF COMPARATIVE ANALYSIS FOR GROUND WATER ALTERNATIVES**

EVALUATION CRITERIA	ALTERNATIVES			
	GW-1	GW-2	GW-3	GW-4
Overall Protection of Human Health and the Environment	Does not provide any protection to human health and the environment.	The remedy is protective. Presently being implemented by MMAG. Has been shown to effectively preclude off-site migration of ground water in the alluvium.	The remedy is protective. More protective to human health and the environment than GW-2 because it would incorporate an additional recovery well system and UV photolysis/oxidation to capture and treat NDMA and UDMH contamination, respectively.	The remedy is protective. Most protective alternative because it specifically addresses all known ground water contamination. In addition to collecting and treating NDMA/UDMH contamination, chromium contamination in the M3 area would be collected and treated by chemical reduction/precipitation/clarification.
Compliance with ARARs	Not applicable.	Complies with all ARARs and meets MMAG's COPDES permit requirements.	Complies with all ARARs and would meet MMAG's COPDES permit requirements.	Complies with all ARARs and would meet MMAG's COPDES permit requirements.
Long-term Effectiveness and Permanence	Natural attenuation processes would occur and ground water remediation goals would be attained at some point in the future (estimated to take in excess of 130 years). At that point, barring any unknown sources, Alternative GW-1 would be considered permanent and effective in the long-term.	Remediation goals would be achieved in 130 years for on-site ground water and in excess of 5 years for off-site ground water. There would be no significant risks associated with long-term exposure since contaminant levels would meet remediation goals.	Remediation goals would be achieved in 45 years for on-site ground water and more than 5 years for off-site ground water. Removal and treatment of contaminated ground water would be effective and permanent with sources removed. There would be no significant risk associated with long-term exposure since contaminant levels would meet remediation goals.	Remediation goals would be achieved in 45 years for on-site ground water and more than 5 years for off-site ground water. Removal and treatment of contaminated ground water would be effective and permanent with sources removed. There would be no significant risk associated with long-term exposure since contaminant levels would meet remediation goals.
Reduction of Toxicity, Mobility, or Volume Through Treatment	Does not involve any treatment and therefore would not provide any reductions to toxicity, mobility, or volume.	Air stripping would effectively remove 99 percent of the VOCs. Carbon adsorption would effectively remove up to 99.99 percent of the remaining organic contaminants. Ion exchange would effectively remove in excess of 99 percent of the inorganic contaminants. Remediation goals and risk-based concentration levels would be met. Satisfies SARA preference for treatment.	Air stripping would effectively remove 99 percent of the VOCs. Carbon adsorption would effectively remove up to 99.99 percent of the remaining organic contaminants. Ion exchange would effectively remove in excess of 99 percent of the inorganic contaminants. UV photolysis/oxidation would effectively remove and destroy in excess of 99 percent of the NDMA and UDMH contamination. Remediation goals and risk-based concentration levels would be met. Satisfies the SARA preference for treatment.	Air stripping would effectively remove 99 percent of the VOCs. Carbon adsorption would effectively remove up to 99.99 percent of the remaining organic contaminants. Ion exchange would effectively remove in excess of 99 percent of the inorganic contaminants. UV photolysis/oxidation would effectively remove and destroy in excess of 99 percent of the NDMA and UDMH contamination. Chemical reduction would effectively remove in excess of 99 percent of the chromium contamination. Satisfies the SARA preference for treatment.

TABLE 7-2 (Continued)

ALTERNATIVES					
EVALUATION CRITERIA	Short-term Effectiveness	Implementability	Cost Capital O&M Present Worth	State Acceptance	Community Acceptance
GW-1	The environment is not protected. There would not be any emissions to the air and consequently no exposure to humans through air.	Easily implemented. Would require decontaminating existing recovery well systems. Would be implemented in less than one year.	\$0 \$160,000 \$2,800,000	Unacceptable.	No comments received. Assumed unacceptable.
GW-2	Alternative GW-2 would not be effective in the short-term. However, public health and the environment are protected during implementation.	Alternative GW-2 is presently in operation and, therefore, has the highest rating with respect to implementability.	\$0 \$514,000 \$7,900,000	Acceptable to the State.	No comments received.
GW-3	Alternative GW-3 would not be effective in the short-term. Environmental degradation would be minimized off-site. However, public health and the environment are protected during implementation.	Alternative GW-3 would be implemented with little difficulty. Conventional recovery system would be used to construct the additional UV photolysis/oxidation system and the UV photolysis/oxidation system would be obtained from a vendor and implemented as part of MMAAG's existing WTP. Construction of the additional recovery well system and the NDMA/UDMH treatment process would take less than one year.	\$1,100,000 \$1,100,000 \$18,000,000	Acceptable to the State.	No comments received. Assumed acceptable.
GW-4	Alternative GW-4 would not be effective in the short-term. Environmental degradation would be minimized off-site. However, public health and the environment are protected during implementation.	Alternative GW-4 would be implemented with little difficulty. Conventional equipment would be used to construct the additional recovery system and the UV photolysis/oxidation system would be obtained from a vendor and implemented as part of MMAAG's existing WTP. The chromium treatment process is already in place at MMAAG for use with their industrial waste stream. Construction of the additional recovery well systems and the NDMA/UDMH treatment process would take less than one year.	\$1,300,000 \$1,100,000 \$18,200,000	Acceptable to the State. State concurs with GW-4 as the selected remedy.	No comments received. Assumed acceptable.



Alternative GW-4 again is protective and reduces uncertainty associated with Alternative GW-3 by including an additional recovery well system in the M3 area to collect a chromium plume that originates in the M3 area. In addition, a chemical reduction/precipitation/clarification process would be used to remove the chromium and any other metals as well as other inorganic contaminants from the ground water. Alternative GW-4 does not result in any reduction to the ground water restoration time frame when compared to alternative GW-3, but it does address a known contaminated plume.

### **7.3.2 Compliance with ARARs**

Chemical-, location-, and action-specific ARARs were identified for the MMAG site and ground water alternatives developed. The full ARARs analysis is presented in Appendix A of the feasibility study (Geraghty & Miller, 1990b).

Alternative GW-1 may attain, in 200 years, the chemical-specific ARARs. Alternatives GW-2, GW-3, and GW-4 would comply with all ARARs. Since Alternatives GW-2, GW-3, and GW-4 would all collect and treat for detectable contaminants, each would equally comply with ARAR.

### **7.3.3 Long-term Effectiveness and Permanence**

Long-term effectiveness and permanence are the measure of how long into the future the remedy will last and how protective it is during that time. Considering that the ground water would eventually be restored (by natural attenuation in the case of GW-1 or by active treatment in the case of Alternatives GW-2, GW-3, and GW-4), all the alternatives would provide adequate long-term effectiveness and all would be permanent assuming that there are no unknown sources that would prevent restoration. However, alternatives GW-2, GW-3 and GW-4 assure long term effectiveness by using active treatment.

### **7.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment**

Alternative GW-1 does not involve treatment of contaminants. However, the natural attenuation processes that occur would reduce the toxicity and volume of contaminated ground water.

Alternatives GW-2, GW-3, and GW-4 would effectively use the recovery well systems to reduce the mobility of contaminants. Alternative GW-4 would provide the greatest reduction in contaminant mobility for the short-term followed by GW-3 then by GW-2, predominantly because of

the number of recovery systems employed. Residuals such as sludge from treatment processes would be treated and disposed of off-site to ensure meeting this criteria for each alternative.

Alternatives GW-2, GW-3, and GW-4 would also reduce the toxicity of contaminants through treatment that removes contaminants from the ground water. Alternative GW-4 would achieve the highest reductions, followed by GW-3 and GW-2 primarily because it addresses all contaminants of concern including chromium and NDMA and UDMH.

### **7.3.5 Short-term Effectiveness**

None of the alternatives will reduce the threat in the short-term because it may require 45 years or more to attain remediation goals. However, GW-2, GW-3, and GW-4 are protective because ground water is not currently used for human consumption and an alternative water supply will be provided during implementation of the remedy should the need arise.

The ground water treatment process, air stripping, releases low levels of volatile organic chemicals into the air. However, the release will be subject to air pollution controls which will protect human health and the environment.

Environmental degradation would be reduced by Alternatives GW-2, GW-3, or GW-4. GW-4 would be most beneficial to reducing environmental degradation in the short-term followed by GW-3.

### **7.3.6 Implementability**

Alternative GW-2 ranks the highest with respect to implementability, because it is already in operation. Alternative GW-1 would be easily implemented by shut down of present operation.

Implementation of Alternatives GW-3 and GW-4 would require installation of wells or trenches, construction of small diameter pipelines, and process modifications to MMAG's IWTP. This makes GW-3 and GW-4 the most technically difficult to implement.

### 7.3.7 Cost

MMAG estimated capital, operation and maintenance (O&M), and present worth costs for each alternative. The costs are presented below:

<u>Alternative</u>	<u>Capital</u>	<u>Annual O&amp;M</u>	<u>Present Worth</u>
GW-1	\$0	\$180,000	\$2,800,000
GW-2	\$0	\$514,000	\$7,900,000
GW-3	\$1,100,000	\$1,100,000	\$18,000,000
GW-4	\$1,300,000	\$1,100,000	\$18,200,000

MMAG also conducted a cost sensitivity analysis to evaluate how the costs respond to fluctuations in various factors such as volumes, interest rates, and unit costs. The results of the sensitivity analysis are summarized below.

#### SENSITIVITY ANALYSIS OF PRESENT WORTH COSTS

<u>Alternative</u>	<u>Low Cost</u>	<u>High Cost</u>
GW-1	\$1,400,000	\$4,300,000
GW-2	\$3,400,000	\$13,100,000
GW-3	\$7,500,000	\$30,600,000
GW-4	\$7,700,000	\$32,800,000

The sensitivity analysis indicates that approximately the same level of uncertainty exists for each alternative. This is reasonable since Alternatives GW-2, GW-3, and GW-4 all employ similar processes and operate under similar conditions.

### 7.3.8 State Acceptance

The no action alternative is not acceptable to the State of Colorado (CDH). CDH supports EPAs selection of Alternative GW-4 for ground water remediation.

### **7.3.9 Community Acceptance**

Community acceptance of the ground water alternatives is assumed to be in concurrence with the State and EPA. No significant comment regarding the ground water alternatives was received during the public comment period on the proposed plan.

## **8.0 SELECTED REMEDY**

The selected remedy combines two alternatives: S-5 for treatment of contaminated soil and waste from the Inactive Site Ponds and the soil in Chemical Storage Tank area, and GW-4 for contaminated ground water treatment.

The selected remedy addresses the remedial action objectives by including remediation of the principal threat at the site, the Inactive Site area, which contains highly concentrated and mobile contaminants and the soil in the Chemical Storage Tank area. Remediation of ground water is also part of this remedy. As a result of these actions, surface water on-site is expected to be remediated also.

Both EPA and CDH have evaluated the alternatives and agree that this remedy will provide the most effective measures to ensure long term protection of human health and the environment satisfying requirements under CERCLA and attain the ARARs from other Federal and State regulations. In particular, the remedy is consistent with anticipated elements of RCRA corrective action as well as closure standards for RCRA hazardous waste units. These considerations are particularly important because it is anticipated that the remedy will be implemented under the RCRA corrective action authority.

The remedy does not specifically address contamination which originates from Air Force (PIKS) property. However, because ground water in Brush Creek and Dry Gulch will be intercepted, contaminants from Air Force property will be treated also. At this time, contamination in Lariat Gulch will not be addressed by this remedy, except that monitoring will be conducted. The U.S. Air Force and EPA are expected to address Lariat Gulch as part of the Interagency Agreement for that site.

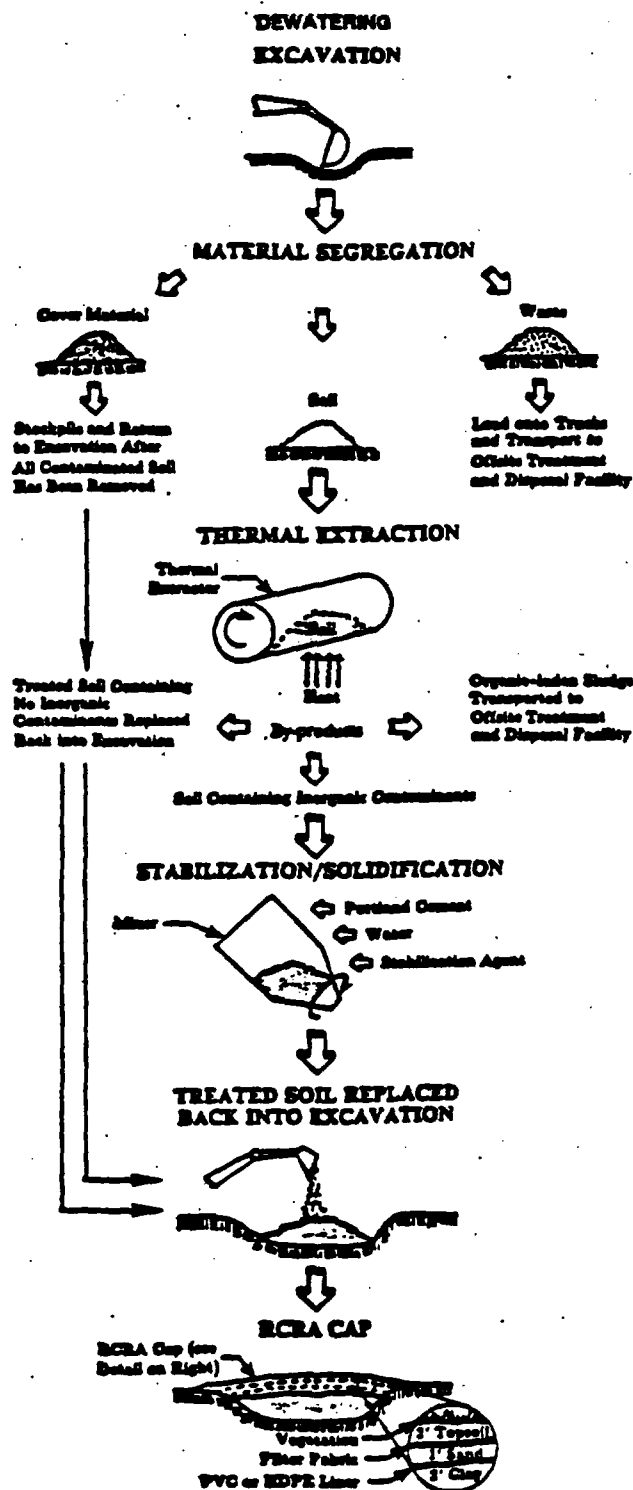
## 8.1 DESCRIPTION

### 8.1.1 Alternative S-5: Dewater/Off-Site Incineration and Disposal of Waste/Thermal Extraction of Backfill and Alluvium/Ex-Situ Stabilization of Backfill and Alluvium/RCRA Cap/In-Situ Soil Vapor Extraction

Specifically, the objectives of this portion of the selected remedy are to mitigate the impact that the Inactive Site Pond area contamination is having on ground water and to reduce the potential for further migration of chlorinated organic chemicals from the Chemical Storage Tank area. The remedy is designed to address both the immediate need to control the source of contamination to another media (ground water) and prevent the potential for future exposure of humans to contaminants at both areas. In order to provide a permanent solution, organic contaminants will be removed and inorganic contaminants will be immobilized at the Inactive Site, infiltration of precipitation through the Inactive Site will be reduced, and organic contaminants from the Chemical Storage Tank area will be removed.

Alternative S-5 incorporates the following components for the Inactive Site area: dewatering of the perched water; excavation, off-site incineration, and off-site disposal of the waste in accordance with LDRs; and excavation, thermal extraction and stabilization of contaminated backfill and alluvium. The treated backfill and alluvium will be placed back into the excavation, and covered with a multi-layered cap over the Inactive Site area. In-situ soil vapor extraction will be used to remove VOCs at the Chemical Storage Tank area. In addition, this alternative includes the off-site incineration and disposal of the residual organic laden sludge from the thermal extraction process and the off-site incineration and disposal or regeneration of the carbon from the in-situ soil vapor extraction process and the thermal extraction air treatment system. This portion of the remedy will be implemented within approximately 4 years. Figure 8-1 depicts the selected remedy for the Inactive Site.

Approximately 1.3 million gallons of perched water will be extracted and treated along with the contaminated ground water. The waste material, approximately 2,100 cy, will be excavated, and transported, and incinerated off-site. The proposed facility is Rollins in Deerpark, Texas. However, any off-site facility used as part of this remedy must satisfy the requirement in section 121(d)(3) of CERCLA.



**FIGURE 8-1- MARTIN MARIETTA ASTRONAUTICS GROUP  
SELECTED REMEDY FOR THE INACTIVE SITE**

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The contaminated backfill and alluvium would be excavated down to action levels, undergo thermal extraction to remove organic contaminants, and be stabilized to immobilize inorganic contaminants. The organic contaminants in the Chemical Storage Tank area would be permanently removed.

A series of wellpoints will be installed in the perched zones of the Inactive Site to extract water. The water will be temporarily stored in holding tanks and either trucked, pumped, or gravity fed to the IWTP to be treated by the processes discussed in GW-4. The treated water would be discharged in accordance with MMAG's COPDES permit. The dewatering process would take approximately 2 to 3 months to complete.

Excavation of the waste, contaminated backfill, and contaminated alluvium at the Inactive Site will be necessary in order to treat the materials. (No excavation will be required at the Chemical Storage Tank area.) Excavation would be achieved utilizing conventional construction equipment such as backhoes and front-end loaders. Controls for VOC emissions during excavation activities will be evaluated during the design phase.

Material segregation by conventional mechanic equipment will be necessary at the Inactive Site. It is anticipated that three stockpile or staging areas will be necessary: one for the uncontaminated cover material, one for the waste, and one for the contaminated backfill and alluvium. The waste material will be loaded onto plastic-lined trucks and transported off-site to an incinerator and landfill. The backfill and alluvium will then be treated by thermal extraction and stabilization. The cover material will be placed back into the excavation once the excavation and treatment processes are complete. (Cover material is that soil which is uncontaminated or contains constituents below the action levels specified in Table 8-1.) Materials will be stockpiled only to the extent that the site remediation is run in an efficient, cost effective manner.

The waste in the Inactive Site ponds is considered a RCRA Listed Hazardous Waste. The waste, approximately 2,100 cy, will be loaded onto lined trucks and transported to an off-site incinerator permitted to accept F001, F005, and F019 listed wastes. The waste will be treated to comply with the F001 and F005 LDR treatment standards. If incineration is used and residues do not satisfy the LDR treatment standards for F019 (inorganic) wastes, they will be stabilized prior to land disposal in a RCRA Landfill. These activities will be consistent with Section 121(d)(3) of CERCLA.

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TABLE 8-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
SOIL ACTION LEVELS AND TREATMENT STANDARDS**

ORGANIC CONTAMINANTS OF CONCERN	ACTION LEVELS	TREATMENT STANDARDS
<b>VOLATILE ORGANIC COMPOUNDS</b>	<b>TCLP, mg/l<sup>(1)</sup></b>	<b>TCLP, mg/l<sup>(2)</sup></b>
Acetone	0.59	160
1,1-Dichloroethene		7.2
trans 1,2-Dichloroethene		33
Tetrachloroethylene	0.7	0.05
Toluene		0.33
1,1,1-Trichloroethane		0.41
Trichloroethene	0.5	0.091
Xylenes (total)		28
<b>SEMI-VOLATILE ORGANIC COMPOUNDS</b>		<b>Total Conc, mg/kg<sup>(3)</sup></b>
Anthracene		4.0
Benzo(a)anthracene		8.2
Benzo(a)pyrene		8.2
Benzo(ghi)perylene		1.5
Benzo(b+k)fluoranthenes		3.4
Bis(2-ethylhexyl)phthalate		28
Chrysene		8.2
Di-n-butylphthalate		28
Fluoranthene		3.1
Indeno(1,2,3-cd)pyrene		8.2
Phenanthrene		3.1
Pyrene		8.2
1,2,4-Trichlorobenzene		
Phenol		
PCB - 1242	25.0	1.0
PCB - 1248	25.0	1.0
PCB - 1254	25.0	1.0
PCB - 1260	25.0	1.0



TABLE 8-1 (continued)

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
SOIL ACTION LEVELS AND TREATMENT STANDARDS**

ORGANIC CONTAMINANTS OF CONCERN	ACTION LEVELS	TREATMENT STANDARDS
INORGANIC COMPOUNDS	TOTAL CONC, mg/kg <sup>(a)</sup>	TCLP, mg/l <sup>(a)</sup>
Acetone	0.59	
Aluminum	116000	
Antimony		
Barium		100
Beryllium	1.56	
Cadmium	3.2	1
Chromium (Total)	60	5
Copper	4343	
Lead	31	5
Mercury	3.7	0.2
Nickel		
Silver	5	5
Fluoride	25	
Nitrate + Nitrate		
Cyanide (total)		590 mg/kg <sup>(a)</sup>
Cyanide (amenable)		30 mg/kg <sup>(a)</sup>

NOTE: LDR treatment standards are not ARARs for contaminated soil and debris. However, the treatment standards are being used as target cleanup levels. Treatability variances for soil and debris are available. 55 Federal Register, 8760 (March 8, 1990).

1. Regulatory levels for toxicity characteristic constituents as published at 55 Federal Register, (March 29, 1990).
2. Treatment standards published in the at the 55 Federal Register, (June 1, 1990).
3. Treatment standards published at 55 Federal Register, (June 1, 1990)
4. Background levels from the remedial investigation report (Geraghty & Miller, 1990a)
5. Treatment standards for F019 wastes as published, at 55 Federal Register, (June 1, 1990).

On-site, approximately 24,400 cy of contaminated backfill and alluvium will be treated by thermal extraction to remove volatile and semivolatile organic contaminants. Thermal extraction is a low temperature thermal treatment process which volatilizes organic contaminants from the soil matrix. Operating temperatures are low, preventing combustion of the organic contaminants and oxidation of the inorganic contaminants. The process produces an organic-free soil and an off-gas that, when treated, generates waste water, clean air, and an organically contaminated sludge.

A typical thermal extraction system would consist of an extraction vessel and gas treatment system. Material to be thermally treated would be screened and/or undergo size reduction to remove large particles. Several types of thermal extraction processes are available. Selection of the equipment will be performed during the design phase. The off gas treatment system removes contaminants from the gas stream usually with a condenser and particulate collection equipment.

Thermal extraction differs from incineration in several ways. One of the major differences is that thermal extraction is not a combustion process and, therefore, does not have stringent permit requirements. The thermal extraction process operates at significantly lower temperatures compared to incineration. Thermal extraction is accomplished at 300-600°F while incineration requires a minimum temperature of 1,200°F. Thermal extraction contributes less to thermal pollution than incineration because gas exiting the stack is usually within 10°F of ambient air temperatures. Thermal extraction is best suited for low level organic contamination whereas incineration is best for high organic materials with significant heat value.

One of the major differences between thermal extraction and incineration is that thermal extraction is a removal technology and incineration is a destruction technology. As a result, the organic-laden sludge residue generated from thermal extraction, which is on the order of 0.5 to 10 percent of the feed volume, requires additional treatment via incineration to achieve destruction to levels acceptable for land disposal. Incineration is more efficient than thermal extraction at removing organic contaminants. Incineration has a destruction and removal efficiency (DRE) of 99.99 percent compared to a removal efficiency for thermal extraction of up to 99 percent. Mobile or transportable units are available for both technologies.

Following thermal treatment, approximately 24,400 cy of backfill and alluvium would be treated by ex-situ stabilization. The stabilization process incorporates the contaminated soil into a matrix additives such as Portland cement, water, and proprietary compounds to immobilize the contaminants by chemically and physically binding them in-place.

Stabilization processes employ ion exchange, nucleation, chemical bonding, and other chemical reactions to treat contaminated materials. Removing the organic contaminants by thermal extraction will increase the effectiveness of stabilization.

Stabilization can be performed in an open pit, in concrete trucks, and in fabricated systems designed specifically for stabilization. Both stationary and mobile systems, are available. The backfill and alluvium would be mixed with additives in a manner to be determined during the design phase. The mixed product will be placed back into the excavation and capped.

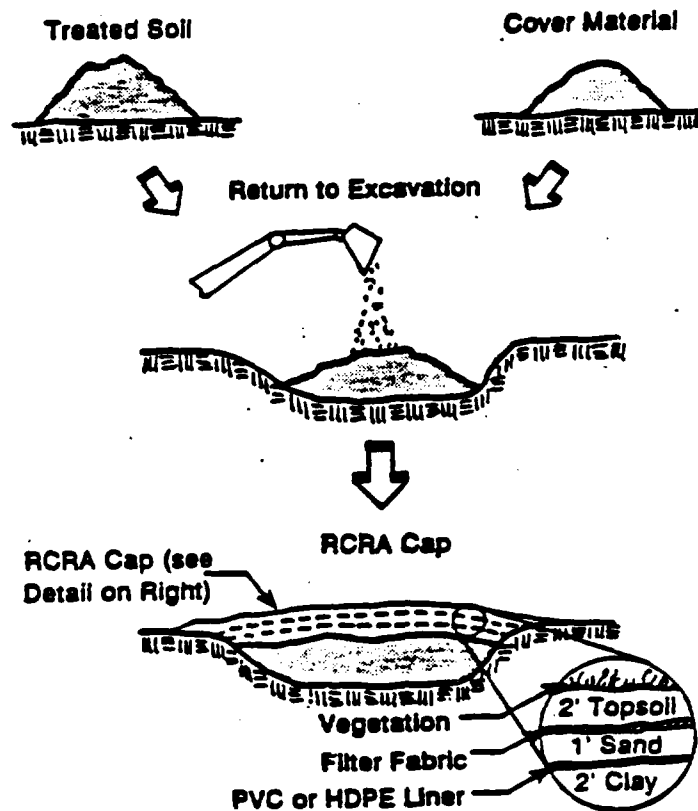
The remediation goal for treatment of the contaminated soil is to meet LDR treatment standards for the waste types identified above. If pilot scale treatability studies demonstrate that treatment levels specified by LDR standards cannot be achieved, a treatment level based upon soil and debris variances will be established. The combination of removing organic contamination and immobilizing inorganic contamination will protect ground water from contaminant leaching and reduce the potential for direct contact with contaminated soil.

A multi-layered, engineered cap will be installed to cover any area where treated soil is returned to the Inactive Site. The cap will be consistent with RCRA capping design standards for land disposal units.

A RCRA cap is proposed for covering the Inactive Site area, following replacement of treated materials. This may include the five ponds and the area adjacent to the ponds as depicted in Figure 8-2. The extent of capping will be determined during the design phase. A RCRA cap was selected because it is the best demonstrated available technology. It provides a high degree of effectiveness at a reasonable cost and is easily maintained.

The RCRA cap would consist of an upper vegetated layer underlain by a drainage layer over a low permeability layer as shown in Figure 8-2. The low permeability layer can be composed of natural soil, admixed soil, a synthetic liner, or any combination of these materials. A synthetic liner would overlay the low permeability natural soil or soil admix. The synthetic liner allows minimal liquid penetration for a minimum of 20 years as long as it is properly installed and maintained in accordance with the manufacturer's instructions. The low permeability soil layer provides additional protection in the event the synthetic liner fails.

Relative to other capping options, the RCRA cap requires little maintenance. Since most of the cap is composed of natural materials, erosion and settlement are the major concerns. Both



**FIGURE 8-2 - MARTIN MARIETTA ASTRONAUTICS GROUP  
RCRA CAPPING PROCESS**

concerns would be minimized by establishing and maintaining a healthy vegetative cover. The cap would be inspected regularly for the design life of the cap.

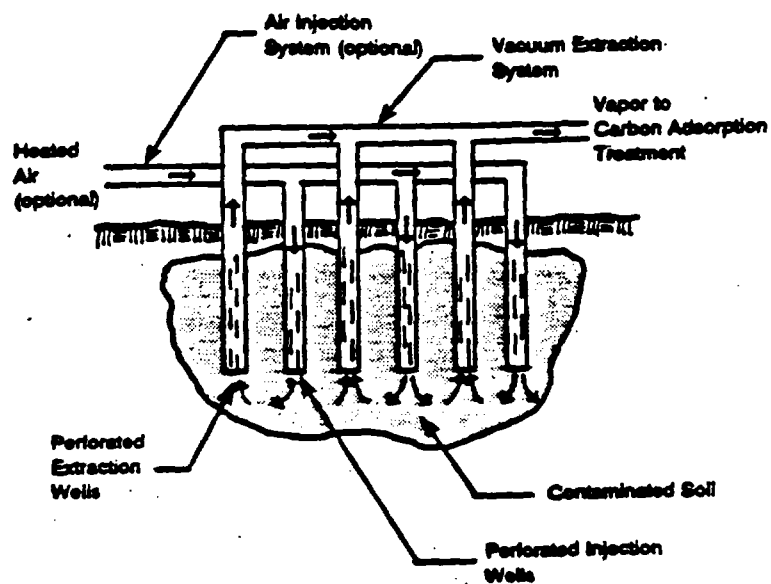
Ground water monitoring will be conducted around the Inactive Site to monitor potential contaminant migration from the area. Soil samples will be collected from the Chemical Storage Tank area to evaluate the treatment effectiveness.

The Site will be monitored on a routine basis consistent with RCRA requirements to determine if the remedy is effectively reducing contaminant levels in the ground water and if the source control measures effectively preclude contaminant loading on the ground water. Post-closure monitoring is required and will be performed annually or more frequently.

During the RI/FS process, bench scale treatability tests were performed on Inactive Site materials to study thermal and stabilization treatment. The analysis of the treatability test results is reported in the test report (Geraghty & Miller, 1987b). In general, the test results were supportive of the selected remedy. The thermal treatment testing demonstrated that both semi-volatile and volatile organic compounds are removed from pond samples at a treatment temperature of 1022°F (550°C) but not at 220°F (104°C). The test results report concluded that removal efficiencies of greater than 99% were achieved. The stabilization testing results concluded that cement based treatment will reduce mobility of contaminants and proposed treatment additive ratios. However, the test results cannot be used for the purpose of remedial design.

Additional treatability testing of thermal vapor extraction and stabilization/solidification must be performed to support the design phase activities. This treatability testing will be used to verify the effectiveness of the treatment processes and establish operating parameters for design of full scale equipment.

In-situ soil vapor extraction would be used to remove TCE and 1,1,1-TCA from the Chemical Storage Tank area subsurface soil. The in-situ soil vapor extraction process is depicted in Figure 8-3. A series of extraction wells connected to a vacuum pump would be installed in and around the Chemical Storage Tank area such that the cones of influence would extend over the entire contaminated area. A series of injection wells connected to a blower or vacuum pump would be placed in and around the Chemical Storage Tank area and used to induce air flow through the soil to strip and volatilize the VOCs into the air stream. Subsurface air, VOC vapors, and water vapors would migrate toward the vacuum extraction wells in response to the negative pressure gradient around the well.



**FIGURE 8-3 - MARTIN MARIETTA ASTRONAUTICS GROUP  
SELECTED REMEDY FOR CHEMICAL STORAGE AREA  
IN-SITU VAPOR EXTRACTION**

The contaminated air and vapor would flow to a vapor/liquid separator where contaminated water would be removed. The contaminated water would be treated to meet COPDES limits in MMAG's industrial waste water treatment plant. The contaminated air stream would be treated to reduce VOC concentrations to air quality standards. Air emissions would be monitored and additional controls would be incorporated as necessary.

Soil vapor extraction is expected to achieve an estimated 99% removal of VOCs which will provide long term protection of the ground water by further reducing the potential for contaminant leaching into the saturated zone.

**8.1.2 Alternative GW-4: Continued Operation of Existing Recovery Well Systems/Installation of Additional Recovery Well Systems In Filter Gulch and Dry Gulch Upgradient From the Existing Recovery Well Systems/Addition of a Recovery Well System in the M3 Area/Treatment By Chemical Reduction, Precipitation, Clarification, Air Stripping, Carbon Adsorption, Ion Exchange, and/or UV Photolysis-Oxidation/Discharge to Brush Creek**

Because the ground water supplied both domestic and agricultural water, and there is a potential for the ground water to be used for these purposes in the future, alternative GW-4 is selected to restore ground water to its beneficial uses. Presently, the ground water is contaminated with VOCs, semi-volatiles and chromium at levels that pose significant health threats were the water used is for domestic purposes.

Ground water Alternative GW-4 will preclude contaminated migration off-site in the alluvial ground water by removing organic and inorganic contaminants from the alluvial ground water to meet remediation goals. Additionally, ground water in the Fountain Formation in the vicinity of the Chem Mill and Hydrostat Tank areas highly contaminated with VOCs and chromium will be collected and treated.

The ground water response action is generally limited to the alluvial system, except for ground water in the M3 area. The basis for this decision is the fact that bedrock flow is extremely low relative to the alluvial flow, contaminant migration is primarily directed down-dip and subsequently confined by a shale formation as described in section 4.3.1. Additionally, bedrock would not yield sufficient water to be used for domestic or agricultural purposes. However, monitoring of bedrock and alluvium will be conducted to evaluate migration of contaminants in the bedrock, and remediation goals are likely to be met at some point in the future as a result of natural attenuation and the other response actions.

The ground water will be recovered from the five systems and pumped to the IWTP in the M3 area where organic and inorganic contaminants will be removed. The IWTP would include air stripping, carbon adsorption, ion exchange, UV photolysis/oxidation, chemical reduction, precipitation, and clarification processes. Ground water may be treated separately through some of the processes. Only, chromium contaminated water would proceed through the chromium removal step. The treated effluent would be discharged to the Brush Creek MMAG waste water outfall (COPDES Permit #0001511), located approximately 100 feet downstream of the Brush Creek recovery system, as shown in Figure 8-4.

Ground water modeling indicates that ground water restoration time frames required to attain restoration goals are approximately 45 years for on-site ground water and in excess of 5 years for off-site ground water. The model assumes that sources of contamination are completely removed. Given this assumptions and others, the length of time required for ground water restoration is only an estimate.

Ground water monitoring will be conducted semiannually, at a minimum, through sufficient number of wells to track contaminant migration from the site to assess potential risks. Exact well locations will be determined during the design phase. The monitoring would be done in the following areas:

M3, Filter Gulch, and Kassler:

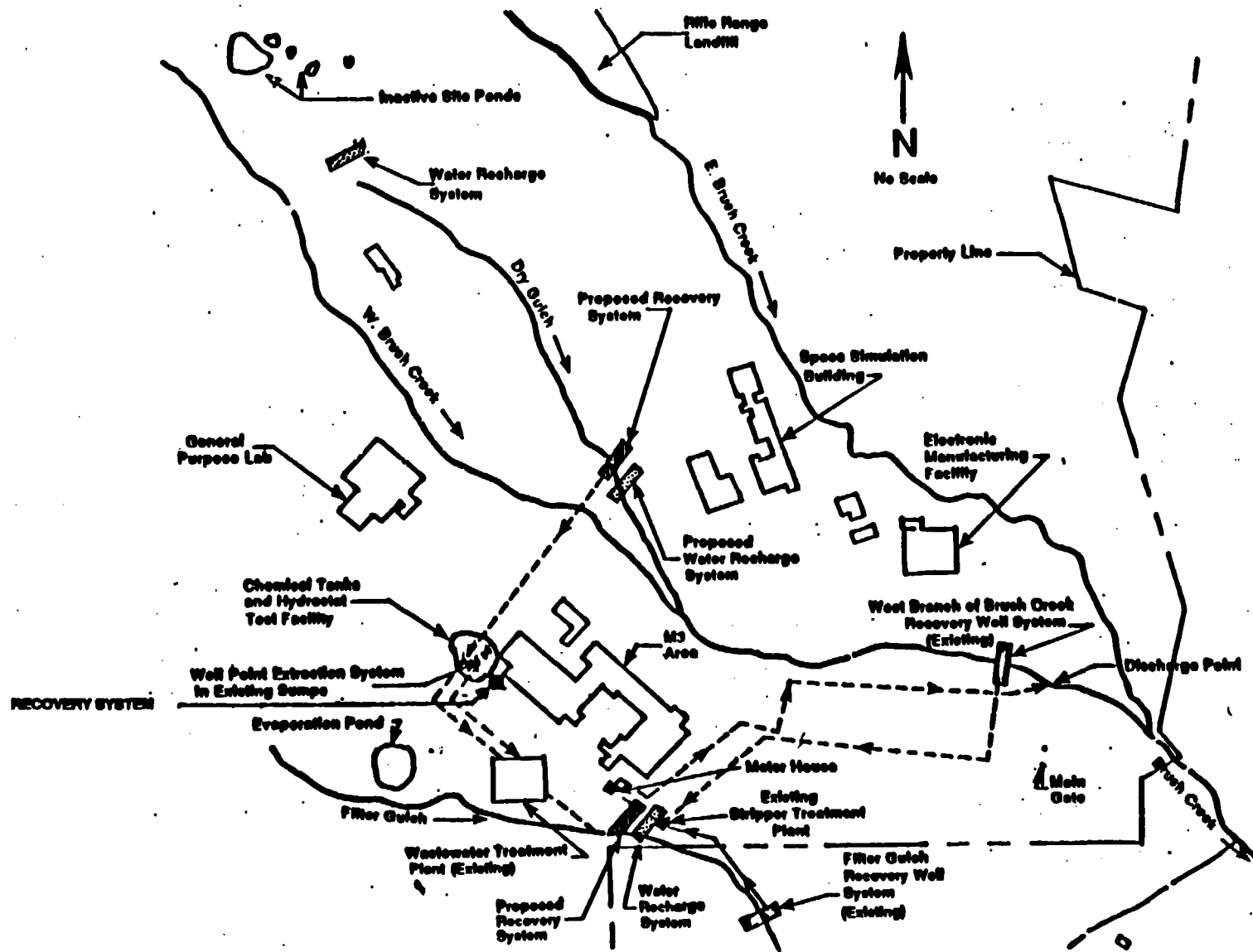
Alluvium

- Up and down-gradient of the Evaporation Pond
- In the central M3 area near Mod C along Filter Gulch, both above and below the Filter Gulch recovery system
- At the mouth of Filter Gulch in the Kassler area

Bedrock

- Downgradient from the Chemical Tanks at the north door of the factory
- Downgradient from the evaporation pond
- In the central M3 area near Mod C
- Downgradient from the former location of the EHT
- On the south side of Filter Gulch, southeast of the Evaporation Pond





**FIGURE 8-4 - MARTIN MARIETTA ASTRONAUTICS GROUP  
PROPOSED GROUND WATER RECOVERY SYSTEMS**

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- Along Filter Gulch, both above and below the existing Filter Gulch recovery system
- At the mouth of Filter Gulch in the Kassler area

Inactive Site Area:

Alluvium

- Along alluvial ground water pathways directly north of the ponds approximately 400 feet downgradient (south) of Pond 1
- Along Dry Gulch at locations approximately 1,000 feet, 2,100 feet, and 4,000 feet downgradient of the ponds
- Along the West Branch of Brush Creek approximately 300 feet south-southeast of Pond 1

Bedrock

- Approximately 180 feet north of Pond 4
- Along the West Branch of Brush Creek, 300 feet south-southeast of Pond 1
- Approximately 400 feet south-southeast of Pond 1
- Along Dry Gulch at locations 1,000 feet, 2,100 feet, 2,700 feet, and 4,000 feet south-southeast of the ponds
- In the Lyons Sandstone 1,000 feet east-northeast of the ponds

Brush Creek (East and West Branches) and Kassler:

Alluvium

- Along the West Branch at the confluence with Dry Gulch
- Above and below the Lower Brush Creek recovery system
- Along the East Branch, downgradient from the Rifle Range Landfill
- Along the East Branch above the confluence with the West Branch
- In the South Platte alluvium along Brush Creek, near the 5-sided well and upgradient from the Department of Wildlife ponds

Bedrock

- Along the West Branch at the confluence with Dry Gulch

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- In the Glennon Limestone near the West Branch
- In the South Platte/Lytle Formation below the Lower Brush Creek recovery system
- Downgradient from the Rifle Range Landfill

**North Central Valley:**

**Alluvium**

- Along the southern extension of Lariat Gulch, 800 feet north of the Air Force property boundary and 1,600 feet north of the boundary at the confluence of the southern extension with the main branch of Lariat Gulch

**Bedrock**

- Along the southern extension of Lariat Gulch 800 feet north of the Air Force property boundary

The RCRA Part B and Post-closure permits will place restrictions on the installation of new ground water supply wells and provisions for MMAG to provide an alternate water supply should the need arise during the implementation of alternative GW-4.

One of the new recovery systems will be installed in Dry Gulch in a more highly contaminated area, approximately 3,500 feet southeast of the Inactive Site, and another will be installed in Filter Gulch southeast of the M3 area, approximately 200 feet north of the MMAG property boundary. The new recovery system in Dry Gulch will probably consist of a trench and well system similar to the existing Brush Creek system. The new system in Filter Gulch would probably consist of a line of recovery wells similar to the existing Filter Gulch system. Water purchased from the Denver Water Department would be recharged into the alluvium at Dry Gulch and the M3 area to enhance extraction rates and flushing of the alluvium for more rapid restoration. Additionally, a recovery system will be installed in the Clean Mill Sumps and extraction wells will be placed near the HTT area.

It may also be necessary to install an extraction system upgradient of the Inactive Site recharge system to collect ground water located between the ponds and the recharge system. The need for such a system would be evaluated during the design phase. Figure 8-4 provides a summary of all the ground water recovery system locations.

Extracted ground water will be treated by chemical reduction, precipitation, air stripping, carbon adsorption, ion exchange, and UV photolysis/oxidation, chemical reduction, and chemical

precipitation (See Figure 8-5). The process design and final methods of treatment will be determined during design phase.

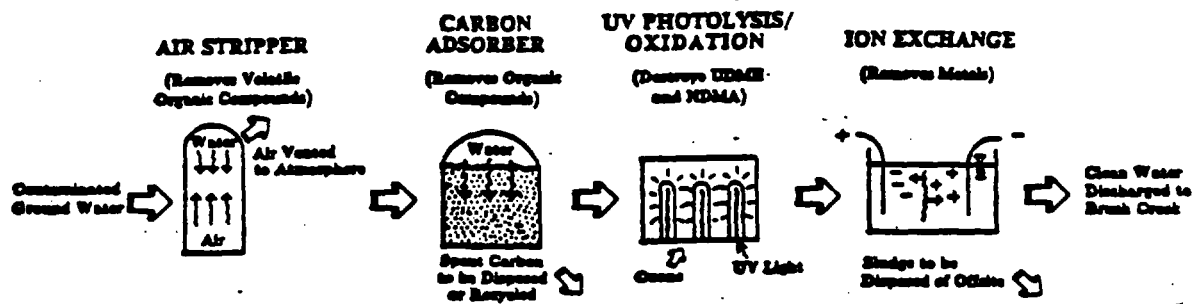
Air stripping is a widely used process for removing VOCs from aqueous streams. The degree to which the contaminant enters the gaseous phase depends on a combination of physical and chemical characteristics of the contaminant such as the diffusivity, molecular weight, solubility, and vapor pressure, as well as the design of the aeration system employed. One of the more important characteristics of a volatile organic compound is its Henry's Law constant. The greater the Henry's Law constant for a particular VOC, the easier a VOC is removed from water by aeration. The Henry's Law constant is a function of temperature, therefore, the water temperature will also affect the amenability of a contaminant to removal by aeration.

Air stripping is generally used to remove VOCs that have a Henry's Law constant greater than  $3.0 \times 10^3$  atm-m<sup>3</sup>/mole from aqueous liquids and would effectively remove ground water contaminants such as TCE, DCE, and toluene found at the MMAG site.

The air stripping system in use at MMAG is a counter-current packed tower. Water is introduced at the top of the tower and flows by gravity through packing media, which serves as the mass transfer surface area. At the same time, air is blown upward through the tower in a counter-current flow. The air is exhausted through the top of the tower. The process transfers organic contaminants from the wastewater to the air stream. The treated effluent is removed from the bottom of the tower, collected in a sump, and pumped to the carbon adsorption unit.

The principal environmental concern associated with air stripping is the generation of volatile organic air emissions. As part of the final remedy, EPA and CDH have decided to include, as part of the air stripping process, an activated carbon adsorption emission control system. The emission control system is added to comply with the national policy (OSWER Dir. 9355.0-28) calling for emission controls for air stripping in areas of non-attainment with respect to ambient air quality standards. Additionally, the response actions are intended to reduce contaminant toxicity, mobility or volume in the environment and not cause cross-media contamination. This decision is not based solely on cancer risk considerations. The justifications for this decision include community acceptance and the need to control VOC emissions to reduce atmospheric impacts on ozone.

Liquid effluent from the air stripper will be sent to the carbon adsorber. Carbon adsorption removes the organic contaminants from the liquid stream by absorbing them onto a high surface area activated carbon bed comprised of either granular or powdered carbon. Activated carbon will also



Note: Process flow scheme is representative of remedy but will be subject to the results of pre-design studies.

**FIGURE 8-5 - MARTIN MARIETTA ASTRONAUTICS GROUP  
SELECTED REMEDY FOR GROUND WATER CONTAMINANT  
TREATMENT PROCESS**

adsorb most metals chelated with organic compounds. Factors affecting the adsorption process include the carbon pore structure, carbon contact time, temperature, and pH. Treated effluent from the carbon adsorber would be next processed in the UV photolysis system. Used carbon material would be periodically regenerated or disposed off-site.

Ultra-violet (UV) photolysis is a process that uses UV radiation to destroy or detoxify organic contaminants in aqueous solutions. Oxidation is combined with UV photolysis to enhance the efficiency and rate of the reactions for compounds that are difficult to oxidize. UV photolysis will be used at MMAG to remove NDMA and UDMH from the ground water.

Treatability studies will be required to select the appropriate design for the UV/Oxidation process. Several options exist which include using solar and lamp generated UV light.

The ion exchange process equipment consists of columns containing solid ion exchange resins. These resins contain charged surface sites that are initially occupied by weakly held monovalent anions or cations such as chloride, hydroxyl, sodium, or hydrogen ions. The contaminant ions displace the original ions from the exchange sites and are removed from the wastewater stream as a result of high affinity for the charged sites on the surface of the resins.

Exchange resins are reversible, and are periodically regenerated for reuse. Both anions and cations can be removed from the ground water stream by placing a cation exchange column and anion exchange column in series. This type of system would have the capability to remove a wide range of inorganic dissolved contaminants such as metallic anions and cations, halides, sulfates, and organic acids and bases. The exact configuration of the ion exchange process will be determined during design.

Regeneration of ion exchange resins produces a concentrated solution of contaminants that may require treatment prior to disposal.

Reduction/oxidation may be used to treat hexavalent chromium in the ground water. In this process the oxidation state of one reactant is raised while the other is lowered. This process is used to reduce the toxicity of hexavalent chromium by converting it to the trivalent state. Typical reducing agents used in the process are ferrous sulfate, sulfur dioxide, and sodium chlorohydrate.

The chemical precipitation step is a physicochemical process through which some or all of a substance in solution is transformed into a solid phase. Precipitation would follow the chemical reduction phase to separate the solid metals from the liquid phase. The process is based on altering

the chemical equilibrium relationships affecting the solubility of inorganic species. Precipitation would be used to remove the chromium and other metals from solution. Other inorganic contaminants such as phosphate, sulfate, and fluoride would be removed as necessary.

The removal of metals would be accomplished through the addition of lime, sodium hydroxide, or sodium sulfide to the water in a rapid mixing tank along with flocculating agents. The water would be introduced to a flocculation tank where it would be mixed and retained to allow for agglomeration of precipitate particles. Sedimentation or clarification would be used to settle out the sludge. Precipitation is nondestructive and generates a large volume of sludge that must be disposed.

Sludges, waste residues, and spent carbon resulting from the treatment of the ground water would be analyzed for contaminant content and disposed of accordingly. Sludges will be disposed at an off-site permitted hazardous waste TSD facility. Spent carbon and ion exchange resins would either be recycled (regenerated), and/or disposed off-site.

The treated effluent discharged from the MMAG IWTP will meet the required treatment standards, specified in MMAG's COPDES permit. Modifications to the permit resulting from implementation of this remedy are not expected with the exception of the limit for NDMA which may be lowered.

## 8.2 REMEDIATION GOALS

The selected remedy includes: (1) removal and treatment of waste and contaminated soil in and around the Inactive Site Ponds which act as the contamination source to the ground water; (2) in-situ removal of chlorinated hydrocarbons from the soil in the Chemical Storage Tank area; (3) and recovery and treatment of contaminated ground water on a site-wide basis (excluding Lariat Gulch). The remediation goals are set at concentrations based upon chemical-specific ARARs which will achieve drinking water standards and provide long term protection of the ground water through source control measures. Additionally, the removal and containment of contaminants in soil on-site will prevent future uncontrolled exposure to humans and wildlife. Finally, the remedy will protect the recreational uses of adjacent areas by preventing contaminant loading on the down gradient environment both in the short term during implementation and in the long term after remediation goals are achieved.

The remediation goals are set at levels necessary to provide long-term protection of human health and the environment with, to the extent possible, unrestricted use of the site and adjacent areas and water migrating from the site.

### 8.2.1 Soil Remediation Goals (Inactive Site and Chemical Storage Tank Areas)

The remediation goals for the Inactive Site Pond area are as follows:

1. Dewatering of the Inactive Site Pond area to remove contaminated perched and alluvial ground water to allow for the subsequent removal and treatment of waste and contaminated soil (alluvium and backfill). This water will be treated to meet the COPDES permit standards before discharge. The limits set in the COPDES permit (No. C000001511) are protective of human health and the environment.
2. The waste sludge that is readily differentiated from soil (i.e., based upon visual inspection) will be separated from the contaminated soil (backfill and alluvium) and transported off-site for treatment and disposal at a permitted hazardous waste TSDF. The waste will be identified as restricted waste subject to all RCRA LDRs standards for treatment and disposal (40 CFR Parts 264 and 268). The off-site facility must comply with section 121(d)(3) of CERCLA.
3. The soil that is contaminated with the hazardous substances/constituents from the wastes will be treated to meet the standards, as described below, and replaced in the area of contamination.

Soil in the Inactive Site area will be analyzed to determine if it meets action levels. The action levels for contaminated soil are based upon both the RCRA Toxicity Characteristics (TC) determination established in 40 CFR Part 261 and background concentrations. The numerical standards for each hazardous substance/constituent are determined by the application of the Toxicity Characteristic Leaching Procedure (TCLP). These action levels are selected as being protective of the water resources on- and off-site and reducing the potential for exposure through other pathways.

The TC-based action levels were developed using health-based concentration thresholds including MCLs, RfDs and Risk-Specific Doses (RSDs) for drinking water (FR 55 March 29, 1990 at 11798 to 11877). The limits for individual contaminant concentrations in the leachate are intended to be protective of humans and the environment assuming ground water is a drinking water source.

Soil that is contaminated in excess of the action level will be treated to meet the treatment standards promulgated for the RCRA hazardous waste under the LDRs (Table 8-1). In practice this will mean that soil, including alluvium and weathered bedrock, will be excavated and treated if it is contaminated above action levels. (The ability to excavate weathered bedrock is uncertain and will require evaluation at the time of implementation.)

The treatment standards for restricted RCRA listed hazardous waste, as defined by LDRs, were established based upon BDAT for discrete industrial waste streams, not soil and debris, and these standards are generally not appropriate for soil (FR 55 p. 8760, March 8, 1990). If the pilot



scale treatability studies conducted during the remedy design phase demonstrate that it is not possible or cost-effective to achieve the LDR treatment standards for listed waste, a new treatment standard will be established base upon the soil and debris treatability variance process for CERCLA response and RCRA corrective actions (OSWER Directive 9347.3-06FS, July 1989).

The soils in the Chemical Storage Tank area will be treated in-situ removing VOCs to approximately 99% removal. The target clean up level will be the LDR treatment standards or an appropriate level based upon soil and debris treatability variance guidelines.

### 8.2.2 Ground Water Remediation Goals

The remedy selected for the ground water is designed to address contaminated ground water emanating from both source areas identified during the RI/FS and units regulated under RCRA program. In this way, the remedy is a site-wide program to address the most significant ground water contamination in the alluvium and a portion of the bedrock in the M3 area.

Because ground water at and near the site is a potential source of drinking water, the remediation goal for both on- and off-site is set to allow use of the ground water as drinking water. The chemical-specific levels are based upon MCLs and MCLGs under the Safe Drinking Water Act, Colorado Secondary Drinking Water Standards, Colorado ground water standards, and health based concentrations (for NDMA)(see Table 8-2). Where a contaminant has more than one standard the most stringent applies. (Only MCLGs greater than zero are relevant and appropriate.)

The selected remedy including treatment of contaminated soil and ground water is intended to restore ground water to its beneficial uses which included drinking water and agricultural supply. The data obtained during the RI and evaluation of the remedial alternatives support the conclusion that it is possible to achieve the remedial goal. The remedy will be implemented with the intent of achieving this goal. However, it may become apparent during the operation of the remedy that contaminant levels have ceased to decline and are remaining constant at levels higher than the remediation goals. In such a case, the system performance standards and/or the remedy may be reevaluated based upon the data collected during the regular monitoring program established as part of the remedy.

A potential technical limitation may prevent the remedy from achieving the remediation goal for NDMA in the ground water. The  $10E-6$  cancer risk from NDMA ingestion assuming exposure in drinking water is estimated at 0.0007 ug/l. Using the best available analytical procedures, the existing reliable quantification limit for compliance monitoring is approximately 0.07 ug/l NDMA in

TABLE 8-2

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
GROUND WATER CLEAN-UP STANDARDS**

<u>Contaminant Of Concern</u>	<u>Ground Water<sup>(1)</sup> Concentration (ug/l)</u>	<u>MCLGs<sup>(2)</sup> (ug/l)</u>
<b>ORGANIC CHEMICALS</b>		
Benzene	5	0
1,2-Dichloroethane	5	0
1,1-Dichloroethylene	7	7
N-Nitrosodimethylamine	0.0007 <sup>(4)</sup>	— <sup>(6)</sup>
1,1,1-Trichloroethane	200	200
Trichloroethylene	5	0
Vinyl chloride	2	0
<b>INORGANIC CHEMICALS</b>		
Arsenic	50 <sup>(2)</sup>	0
Barium	1,000 <sup>(1)</sup>	5000
Cadmium	5	5
Chromium	50 <sup>(1)</sup>	100
Copper	1,000 <sup>(2)</sup>	1300
Cyanide (free)	200	200
Fluoride	4,000	4000
Iron	300 <sup>(2)</sup>	— <sup>(6)</sup>
Lead (MCL = 5 @ source)	5	0
Manganese	50 <sup>(2)</sup>	— <sup>(6)</sup>
Mercury	2	2
Nitrate	10,000	10,000
Nitrite	1,000	1,000
Silver	50 <sup>(2)</sup>	— <sup>(6)</sup>
Zinc	5,000 <sup>(2)</sup>	— <sup>(6)</sup>

References

- Standards taken from (unless otherwise noted) Safe Drinking Water Act Maximum Contaminant Level (MCL), Drinking Water Regulations and Health Advisories, EPA Office of Drinking Water, Washington, D.C., April 1990.
- Colorado Human Health Standards for Ground Water, Colorado Water Quality Commission, The Basic Standards for Ground Water, Section 3.11.0, January 15, 1987.
- Colorado Secondary Drinking Water Standards, Colorado Water Quality Commission, Basic Standards for Ground Water, Section 3.11.0, January 15, 1987.
- Based on the Integrated Risk Information System (IRIS). (Also equivalent to the cancer risk level of 10E-6 for drinking water).
- Standards taken from the Drinking Water Act Maximum Contaminant Level Goal (MCLG), Drinking Water, Regulations and Health Advisories, EPA Office of Drinking Water, Washington, D.C., April 1990.
- MCLG standards not set for these constituents.

water. This corresponds to a  $10E-4$  cancer risk. The ability to treat ground water to remove NDMA to a concentration equal to or less than 0.07 ug/l has yet to be demonstrated.

Changes or adjustment to the design or operation of the ground water recovery and treatment systems may be necessary to achieve the remediation goals. This will be determined after implementation and subsequent evaluation of remedy performance.

### **8.3 REVISED COST ESTIMATE**

Table 8-3 is a summary of the total estimated cost for the selected remedy.

## **9.0 STATUTORY DETERMINATIONS**

The selected remedy will comply with all applicable action-specific, chemical-specific and location-specific ARARs.

The selected remedy is consistent with requirements of CERCLA (as amended by SARA) and the NCP. Under Section 121(b) of SARA the selected remedy must satisfy the following fundamental criteria:

1. Protection of human health and the environment
2. Compliance with ARARs or justify a waiver
3. Cost-effectiveness
4. Use permanent solutions and alternative technologies or resource recovery technologies to the maximum extent practicable
5. Satisfy the preference for treatment to reduce toxicity, mobility, or volume as a principal element, or provide an explanation as to why this preference is not satisfied

### **9.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT**

If EPA were to select the No Action alternative as the remedy, the contaminants on-site would continue to be released to ground water and contaminant migration would result in further degradation of water resources on-site and off-site. Ecological impacts could result in the South Platte River and the Chatfield Reservoir. The potential for human exposure to the contaminants would increase and the ground water would remain useable in the future. If ground water were used for domestic purposes, the health risks would exceed acceptable levels for cancer and noncancerous

TABLE 8-3

September 19, 1990

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
TOTAL ESTIMATED COSTS FOR SELECTED REMEDY**

**CAPITAL COSTS**

**ALTERNATIVE S-5: DEWATER/EXCAVATE/INCINERATE AND DISPOSE OF WASTE OFF-SITE/THERMALLY EXTRACT CONTAMINATED BACKFILL & ALLUVIUM/EX-SITU  
STABILIZE CONTAMINATED BACKFILL & ALLUVIUM/RCRA CAP/IN-SITU SOIL VAPOR EXTRACTION**

	ITEM	ESTIMATED QUANTITY	UNIT PRICE	COST	ALTERNATIVE TOTAL COST
1.	Extraction Wells	60 well points	\$830	\$50,000	
2.	Excavation	47,500 cy	40/cy	\$1,900,000	
3.	Transportation of Waste	2,200 cy 165 trips	3,400/trip	\$800,000	
4.	Incinerate and Dispose of Waste Off-Site	2,100 cy	1,800/cy	3,800,000	
5.	Thermal Extraction a) contaminated backfill b) alluvium	9,700 cy 14,700 cy	425/cy**	4,100,000 6,200,000	
6.	Stabilization a) contaminated backfill b) alluvium	9,700 cy 14,700 cy	275/cy**	2,700,000 4,000,000	
7.	RCRA Capping	45,000 sq yd	40/sq yd	1,800,000	
8.	Transportation of Sludge Residue	750 cy 60 trips	3,400 /trip	200,000	
9.	Incinerate and Dispose of Residue Off-Site	750 cy	1,800/cy	1,400,000	
10.	Fence	3,500 ft	10/ft	35,000	
11.	Soil Vapor Extraction (materials and installation costs for vacuum wells and pumps)			85,000	
	SUBTOTAL			\$26,885,000	
12.	Contingency (@ 20%)			5,377,000	
13.	Engineering, Legal, Administration (@ 25%)			6,721,000	
	ALTERNATIVE S-5 TOTAL			\$38,983,000	\$38,983,000

TABLE 8-3 (continued)

September 19, 1990

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
TOTAL ESTIMATED COSTS FOR SELECTED REMEDY**

**CAPITAL COSTS**

ITEM	ESTIMATED QUANTITY	UNIT PRICE	COST	TOTAL COST
<b>ALTERNATIVE GW-4: PUMPING/EXTRACTION/TREATMENT SYSTEM</b>				
14. Extraction Systems			\$560,000	
15. Piping (Chem Mill Area)	1,000 ft	\$1.50/ft	1,500	
Piping (Remaining Area)	7,000 ft	\$3.50/ft	24,500	
16. Pipe Trench	5,700 ft	\$1.50/ft	7,800	
17. Air Stripper System			38,000	
18. Activated Carbon Filter System			27,500	
19. UV/Ozonation System			164,000	
20. Building Enclosure			50,000	
21. Utilities			30,000	
	SUBTOTAL		\$905,000	
22. Contingencies (@ 20%)			181,000	
23. Engineering, Legal & Administration (@ 25%)			226,000	
<b>ALTERNATIVE GW-4 TOTAL</b>			<b>\$1,300,000</b>	<b><u>\$1,300,000</u></b>
<b>SELECTED REMEDY TOTAL CAPITAL COST</b>				<b>\$40,283,000</b>

TABLE 8-3 (continued)

September 18, 1990

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
TOTAL ESTIMATED COSTS FOR SELECTED REMEDY**

**OPERATION AND MAINTENANCE COSTS**

**ALTERNATIVE S-5: DEWATER/EXCAVATE/INCINERATE AND DISPOSE OF WASTE OFF-SITE/THERMALLY EXTRACT CONTAMINATED BACKFILL & ALLUVIUM/EX-SITU STABILIZE CONTAMINATED BACKFILL & ALLUVIUM/RCRA CAP/IN-SITU SOIL VAPOR EXTRACTION**

ITEM		ANNUAL COST	TOTAL ANNUAL O&M COST
1.	Ground Water Sampling & Analysis	\$17,000	
2.	Cap Maintenance	50,000	
3.	Report Preparation	10,000	
4.	Fence Repairs	4,000	
5.	Ground Water Sampling & Analysis	5,000	
6.	Equipment Repairs	1,000	
7.	Electricity	1,000	
8.	Report Preparation	3,000	
9.	Contingency (@ 20%)	18,000	
10.	Engineering, Legal, Administration (@ 25%)	<u>\$ 23,000</u>	
<b>ALTERNATIVE S-5 TOTAL</b>		<b>\$132,000</b>	<b>\$132,000</b>

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
TOTAL ESTIMATED COSTS FOR SELECTED REMEDY**

**OPERATION AND MAINTENANCE COSTS**

**ALTERNATIVE GW-4: PUMPING EXTRACTION/TREATMENT SYSTEM**

<b>ITEM</b>		<b>ANNUAL COST</b>	<b>TOTAL ANNUAL O&amp;M COST</b>
11.	Extraction Systems	\$67,000	
12.	Piping, Inspection, Testing and Maintenance	7,000	
13.	Treatment Systems	580,000	
14.	Ground Water Monitoring	\$156,000	
	<b>SUBTOTAL</b>	<b>\$790,000</b>	
15.	Contingency (@ 20%)	\$158,000	
16.	Engineering, Legal & Administration (@ 25%)	\$198,000	
<b>ALTERNATIVE GW-4 TOTAL</b>		<b>\$1,100,000</b>	<b>\$1,100,000</b>
<b><u>SELECTED REMEDY TOTAL O&amp;M COSTS</u></b>		<b>\$1,232,000</b>	<b>\$1,232,000</b>
<b>SUMMARY OF SELECTED REMEDY</b>			
<b>TOTAL CAPITAL COSTS</b>		<b>\$40,283,000</b>	
<b>TOTAL OPERATION AND MAINTENANCE COSTS</b>		<b>\$1,232,000/YR</b>	
<b><u>TOTAL COST - Net Present Value</u></b>		<b>\$59,222,000</b>	

(Net present value calculated using 5% discount value and a 30 year project life, present worth factor = 15.3725)

threats (in other words cancer risks above  $1 \times 10^{-5}$ ).

The selected remedy will substantially decrease the release and threat of release of hazardous substances, pollutants and contaminants from the soil and ground water at the Site. The current threats and any potential future threats associated with domestic use of the ground water will be addressed by treating and removing the sources of ground water contamination and treating the ground water to meet drinking water standards. In terms of short term effectiveness, the remedy is adequate as there are no current users of the ground water, an alternate water supply will be provided if needed, and contaminant migration and release will be reduced with the implementation of the remedy. Threats to the environment or human health on and around the site are not expected during the implementation of the remedy because the emissions and discharges will meet health based and regulatory standards.

Achieving the goals of remediation for the ground water remediation is estimated to require 45 years. However, the source control measures at the Inactive Site Ponds will be completed in approximately 4 years. The combination of two alternatives will provide short-term and long-term protection of the environment and human health.

As an additional measure, because the selected remedial action results in hazardous substance, pollutants or contaminants remaining at the site, the remediation will be reviewed at least every 5 years after the initiation of the remedy to assure human health and the environment are being protected.

## **9.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) OF ENVIRONMENTAL LAWS**

Under Section 121(d)(1) of the CERCLA, remedial actions that leave any hazardous substance, pollutant or contaminant on site must attain a level of control that at least attains standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. A remedial action that does not attain ARARs may be selected only if a statutory waiver is available and determined to be appropriate.

"Applicable" requirements are those clean-up standards, standards of control and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant or contaminant, remedial action, location, or other circumstance at a remedial action site. "Relevant and appropriate" requirements are clean-up standards of control and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not



"applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a remedial action site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited to the particular site. See the NCP (40 CFR Section 300.430) for further information.

The selected remedy will comply with all applicable or relevant and appropriate action-specific, chemical-specific and location-specific ARARs (Table 9-1). The action-specific ARARs apply to operating specific technologies such as incineration or landfilling of hazardous waste. Chemical-specific ARARs are those which set limits on concentrations for individual chemicals such as MCLs for drinking water. Finally, the location-specific ARARs relate to activities that are restricted from occurring based upon site conditions such as flood plains or wetlands.

#### 9.2.1 Resource Conservation and Recovery Act (RCRA) and Toxic Substance Control Act (TSCA)

Off-site transportation, treatment, storage and disposal of listed hazardous waste and PCBs is subject to RCRA, TSCA and CHWA and applicable regulations, as well as Section 121(d)(3) of CERCLA.

On-site treatment of soil containing RCRA hazardous waste and other contaminants, and the redepositing of the treated soil in the area of contamination, will attain ARARs under RCRA. The waste removed from the area of contamination will be treated and disposed off-site. The soil will be treated to meet LDR standards (for the listed waste type) or protective standards based on a soil and debris treatability variance.

RCRA requirements are applicable because soil excavated and treated (by stabilization) will contain a hazardous waste and will be redeposited in the area of contamination. (CERCLA Compliance with Other Laws, Draft, U.S. EPA OSWER Directive 9234.1-01, August 1988). Closure standards for landfills and surface impoundments are applicable. However, redepositing the treated soil in the area of contamination does not trigger minimum technology requirements because it is not a replacement unit and no additional waste from outside the unit is added (Superfund Records of Decision Update, U.S. EPA Publication 9200.5-2161, June 1990). Therefore, the design and operating requirements for Subtitle C landfills (40 CFR Section 301) are not applicable. Also, the RCRA storage unit requirements are not applicable for the purposes of accumulating sufficient waste prior to treatment (U.S. EPA, OSWER Directive 9234.1-01 August 1988, p. 2-12). Furthermore, the material that is identified as waste and the organic contamination extracted from the soil will be shipped off-site for treatment and disposal in accordance with RCRA land disposal

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
<b><u>A. Federal Contaminant Specific ARAR's</u></b>				
Safe Drinking Water Act	42 U.S.C. §§ 300f-300j-26	Establishes standards for drinking water	NO/YES	Relevant and appropriate for ground water that is current or potential source of drinking water.
National Primary Drinking Water Standards	40 C.F.R. Part 141	Establishes standards for public water supply systems (maximum contaminant levels).	NO/YES	MCLs are relevant and appropriate for ground water that is current or potential source of drinking water.
National Secondary Drinking Water Standards	40 C.F.R. Part 143	Establishes welfare-based standards for public water supply systems (secondary maximum contaminant levels).	NO/YES	SMCLs are relevant and appropriate for ground water that is a current or potential source of drinking water. For states that have adopted SMCLs as additional drinking water standards, SMCLs are potential state ARARs.
Maximum Contaminant Level Goals	Pub. L. No. 99-339, 100 Stat, 642 (1986)	Establishes drinking water quality goals set at levels of no known or anticipated adverse health effects, with an adequate margin of safety.	NO/YES	MCLGs above zero are relevant and appropriate for ground water that is or may be used for drinking. MCLGs = zero are TBC.
Clean Water Act	33 U.S.C. §§ 1251-1376			

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
Water Quality Criteria	40 C.F.R. Part 131	Provides for establishment of water quality based on toxicity to aquatic organisms and human health.	NO/YES	FWQC for human health are relevant and appropriate for a current or potential drinking water supply. A prom- ulgated MCL exists.
Clean Air Act	42 U.S.C. §§ 7401-7642			
National Ambient Air Quality Standards (NAAQS)	40 C.F.R. Part 50	Establishes standards for ambient air quality applic- applicable to air emissions from cleanup operations.	YES/-	Requirements related to attain- ment of NAAQS are applic- able when the remedial activity at a CERCLA site (e.g. air stripping is a major source of emissions, consider- ing the aggregate of all source emissions at the site.
National Emissions Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR Part 61	Sets emission standards for designated hazardous pollu- tants.	YES/-	There exists proposed sources at the site which will emit hazardous air pollutants.

**B. Federal Location Specific ARAR's**

NONE

**C. Federal Action Specific ARAR's**

Solid Waste Disposal Act ("SWDA") 40 U.S.C.  
§§ 6901-6987

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
Standards Applicable to Generators of Hazardous Waste	40 C.F.R. Part 262	Establishes standards for generators of hazardous waste (waste determination and manifesting.)	YES/-	Excavation or consolidation of soil and sludge may constitute generation of a RCRA hazardous waste.
Standards Applicable to Transporters of Hazardous Waste	40 C.F.R. Parts 262, 263 and 268	Hazardous waste shipped off-site must comply with this section which adopts DOT transportation standards and manifesting requirements.	YES/-	Applicable where hazardous waste is sent off-site.
Standards for Owners and Operators of Hazardous Waste	40 C.F.R. Part 264	Establishes minimum standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	YES/-	Hazardous waste is treated on and off-site.
● General Facility Standards - Financial Requirements	Subparts B through E		YES/-	If hazardous waste is treated, stored or disposed of, the regulation for design and operation for that unit or process are applicable.
● Use and Management of Containers	Subpart I	Establishes standards for storage of hazardous waste or materials in containers.	YES/-	If containers are used to store waste, requirements will be followed.
● Tanks	Subpart J	Establishes standards for use of tanks to treat or store hazardous wastes.	YES/-	If waste is treated in a tank, substantive standards apply.

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
• Surface Impoundments	Subpart K	Establishes standards to treat, store, or dispose of hazardous wastes.	YES/-	If waste is treated in a tank, substantive standards apply.
• Waste Piles	Subpart L	Establishes standards for storage or treatment of hazardous waste in piles.	YES/-	Temporary storage prior to treatment is not subject to standards.
• Landfills	Subpart N	Establishes standards for disposal of hazardous wastes in a landfill.	NO/NO	Off-site disposal is planned.
• Incinerators	Subpart O	Establishes standards for incinerators.	NO/NO	Off-site incineration is planned. Applies to TSD of wastes.
• Land Disposal Restrictions	Subpart C	Identifies hazardous wastes restricted from land disposal and circumstances under which waste may be land disposed.	YES/-	Applies to TSD of waste and soil containing waste.
Hazardous Waste TSD - Organic Air Emission Standards for Process Vents, Equipment Leaks	40 CFR Parts 264 Subpart AA	Standards for emissions from air stripping of VOCs.	YES/-	Air stripping and thermal extraction are employed by the remedy.
Toxic Substances Control Act	15 U.S.C. §§ 2601-2629		TBC	For soil containing waste, LDR levels are target for clean-up.

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
<b>PCB Requirements</b>	<b>40 C.F.R. Part 761</b>	<b>Establishes storage and disposal requirements for PCB's. PCB's are not present in significant quantities at the site.</b>	<b>NO/YES</b>	<b>If PCBs are found at concentrations above 50 ppm, these will be applicable.</b>
<b>Clean Air Act</b>	<b>42 U.S.C.C. §§ 7401-7642</b>			
<b>National Emission Standards for Hazardous Air Pollutants</b>	<b>40 C.F.R. Part 61</b>	<b>Sets emission standards for designated hazardous pollutants</b>	<b>YES/-</b>	<b>There exists proposed sources at the site which will emit hazardous air pollutants.</b>
<b>National Ambient Air Quality Standards (NAAQS)</b>	<b>40 CFR Part 50</b>	<b>Sets emission standards for carbon monoxide, lead, nitrogen, dioxide, particulate matter, ozone, and sulfur oxides.</b>	<b>YES/-</b>	<b>Applicable to TSD facilities and MMAG. MMAG is a non-attainment area.</b>
<b>Occupational Safety and Health Act</b>	<b>29 U.S.C. §§ 651-678</b>	<b>Regulates worker health and safety.</b>	<b>YES/-</b>	<b>Hazardous waste site activities worker protection will apply. (40 CFR 300.38)</b>
<b>Hazardous Materials Transportation Act</b>	<b>49 U.S.C. §§ 1801-1813</b>			
<b>Hazardous Materials Transportation Regulations</b>	<b>49 C.F.R. Parts 107, 171-177</b>	<b>Regulates transportation of hazardous materials.</b>	<b>YES/-</b>	<b>These standards are applicable to off-site transportation of waste.</b>

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
<b><u>D. State Contaminant Specific ARAR's</u></b>				
<b>Colorado Safe Drinking Water Authorities</b>	<b>C.R.S. § 25-1-107(x), (y)</b>			
<b>Primary Drinking Water Regulations</b>	<b>5 CCR 1003-1</b>	<b>Establishes health-based standards for public water supplies.</b>	<b>NO/YES</b>	
<b>Colorado Water Quality Control Act</b>	<b>C.R.S. §§ 25-8-101 to -703</b>		<b>YES/-</b>	<b>Treated ground water dis- charged to surface water must comply</b>
<b>Basic Standards for Groundwater</b>	<b>Section 3.11.0</b>	<b>Establishes a system for classifying ground water and adopting water quality standards to protect exist- ing and potential benefic- ial uses.</b>	<b>YES/-</b>	<b>Beneficial uses include domes- tic and agricultural.</b>
<b>Basic Standards and Methodologies</b>	<b>5 CCR 1002-8</b>	<b>Establishes basic standards for introduction of sub- stances attributable to human-induced discharges into waters of the State.</b>	<b>YES/-</b>	<b>Discharges will occur as part of the remedy.</b>
<b>Anti Degradation Standard</b>	<b>5 CCR 1002-8</b>	<b>Prohibits water quality degradation which would interfere with or become injurious to existing uses.</b>	<b>YES/-</b>	

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
<b>Ambient Air Quality Standards</b>	<b>5 CCR 1001-14</b>	<b>Sets ambient standards for total suspended particulates, sulfur dioxide, oxides, carbon monoxide, and nitrogen dioxide.</b>	<b>YES/-</b>	<b>MMAG is in a non-attainment area.</b>
<b><u>E. State Location Specific ARAR's</u></b>				
<b>NONE</b>				
<b><u>F. State Action Specific ARAR's</u></b>				
<b>Colorado Hazardous Waste Act (HWA)</b>	<b>C.R.S. § 25-15-101 to -313</b>			
<b>Rules &amp; Regulations Pertaining to Hazardous Waste</b>	<b>6 CCR 1007-3</b>			
• <b>Standards Applicable to Generators of Hazardous Waste</b>	<b>Part 262</b>		<b>YES/-</b>	<b>These requirements will apply to waste excavated and generated during the response action.</b>
• <b>Standards Applicable to Transporters of Hazardous Waste</b>	<b>Part 99, 262, 263 and 268</b>		<b>YES/-</b>	<b>Off-site shipments of waste must be manifested as hazardous waste and comply with all transportation standards.</b>



TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
• Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities	Part 264	See standards below		
• General Facility Standards - Financial Requirements	Subparts B through E		NO/YES	
• Release from Solid Waste Management Units	Subpart F	Standards applying to units which store waste from which a release has occurred (including ground water monitoring and protection standards).	YES/-	The Inactive Site Ponds are SWMUs.
• Closure and Post-Closure	Subpart G	Standards that apply to the controls and monitoring of waste in a unit that is no longer operational.	YES/-	Treated soil containing waste returned to the area of contamination is subject to these standards.
• Use and Management of Containers	Subpart I	Establishes standards for storage of hazardous waste or materials in containers.	YES/-	If containers are used to store waste, requirements will be followed.
• Tanks	Subpart J	Establishes standards for use of tanks to treat or store hazardous wastes.	YES/-	If waste is treated in a tank, substantive standards apply.

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
• Surface Impoundments	Subpart K	Establishes standards to treat, store, or dispose of hazardous wastes.	YES/-	If waste is treated in a tank, substantive standards apply.
• Waste Piles	Subpart L	Establishes standards for storage or treatment of hazardous waste in piles.	NO/YES	Temporary storage prior to treatment is not subject to standards.
• Landfills	Subpart N	Establishes standards for disposal of hazardous wastes in a landfill.	YES/-	The existing area of contamination will be closed as a landfill following treatment and re-depositing of the soil (§ 265.310).
• Incinerators	Subpart O	Establishes standards for incinerators.	NO/NO	Off-site treatment of waste is planned.
• Colorado Financial Requirements	Part 266		YES/-	
Colorado Water Quality Control Act	C.R.S. §§ 25-8-101 to -703			
State Discharge Permit Regulations	5 CCR 1002-2	Point source discharges of wastewater require a permit which establishes standards for specific parameters.	YES/-	Treated ground water discharge limits will comply with the COPDES permit limits or be more stringent.
Colorado Air Quality Control Act	C.R.S. §§ 25-7-101 to -505			

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
Regulation No. 1	5 CCR 1001-3	Establishes emission control regulations for particulates, smokes, carbon monoxide, sulfur oxides, and fugitive particulate emissions.	YES/-	Thermal extraction of organics will meet these standards.
Regulation No. 2	5 CCR 1001-4	Establishes odor emission regulations.	YES/-	
Regulation No. 3	5 CCR 1001-5	Establishes permit requirements for construction or modification of stationary sources and regulations for prevention of significant deterioration.	YES/-	Air stripping and thermal extraction employ source emission.
Regulation No. 6	5 CCR 1001-8	Establishes new source performance standards for incinerators, storage vessels for petroleum liquids, sewage treatment plants, new fuel-burning equipment, and new sources of sulfur dioxide.	YES/-	
Regulation No. 7	5 CCR 1001-9	Regulations to control emissions of volatile organic compounds.	YES/-	VOCs are being treated on-site.
Regulation No. 8	5CCR 1001-10	Sets forth emission control requirements for hazardous air pollutants, including beryllium, mercury and lead.	YES/-	These contaminants are present on-site.

TABLE 9-1

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
FEDERAL AND STATE**

<b>Standard, Requirement Criteria, or Limitation</b>	<b>Citation</b>	<b>Description</b>	<b>Applicable/ Relevant and Appropriate</b>	<b>Comment</b>
Colorado Noise Abatement	C.R.S. §§ 25-12-101 to -108	Establishes maximum permissible noise levels for particular time periods and land use zone.	YES/-	If the remedy causes noise.
Water Well and Pump	C.R.S. §§ 37-91-101	Establishes license require- ments for well construction and pump installation con- tractors and minimum stan- dards for well construction and abandonment to protect against pollution.	YES/-	Applies to recovery and moni- toring wells for ground water.
Water Well and Pump Installation Contractors Regulations	2 CCR 402-2	Establishes regulations for construction and abandonment of wells.	YES/-	Applies to recovery and moni- toring wells for ground water.
Well Permit Regulation	2 CCR 402-4		YES/-	Applies to recovery and moni- toring wells for ground water.

restrictions.

LDRs are applicable to the remedy because the action requires treating waste listed in 40 CFR Part 261. The soil contains listed waste and will be treated in accordance with LDR standards applicable to soil and debris. Presently, the remedy sets the treatment goal at the levels established by EPA in the OSWER Directive: 9347.3-06FS may be used if during the design phase it is determined necessary in order to implement this remedy. The hazardous waste storage standards are not applicable to accumulation of waste prior to treatment, the remedy will meet relevant and appropriate requirements to ensure protection of human health and the environment.

There are no action-specific ARARs addressing the stabilization process. ARARs pertaining to air emissions and noise generation will be complied with. OSHA requirements will also be met.

#### **9.2.2 Clean Water Act (CWA) and Safe Drinking Water Act (SDWA)**

Discharges from the treatment of water from the Inactive Site or ground water contaminated with RCRA hazardous waste, will meet limits established under the State and Federal Clean Water Acts. Discharge limits for each chemical parameter are established in the COPDES permit. Additionally, the discharge will be required to comply with water quality criteria for protection of human health.

Ground water will be treated to meet chemical-specific standards specified by the Safe Drinking Water Act (these being, MCLGs, MCLs) and a health-based concentration threshold for NDMA and State Standards, whichever are more stringent. (Only MCLGs which are above zero are relevant and appropriate.)

#### **9.2.3 Clean Air Act (CAA)**

Air emissions from the thermal extraction system, the air stripper for ground water and the soil vapor extraction system will comply with requirements specified in Table 9-1. Spent carbon from the granular activated carbon treatment of vapors will either be disposed of via incineration and disposal (landfill) or regenerated at an off-site location.

### **9.3 COST-EFFECTIVENESS**

The selected remedy offers the best combination of effectiveness, implementability and cost in comparison with the alternatives evaluated. The remedy mitigates and minimizes threats to and is protective of public health and the environment.

Alternatives S-5 and GW-4 provide a high degree of overall effectiveness based upon the criteria of long-term effectiveness and permanence, reduction in toxicity, mobility and volume through treatment of the contaminants on-site, and achievement of short-term effectiveness during implementation.

Compared with alternative S-4 which would be equally as effective, S-5 is less costly. Alternative S-5 is nearly equivalent in cost to S-3 and provides better long-term effectiveness. Alternative GW-4 provides the most extensive cleanup of ground water of any alternative and has one of the shortest restoration timeframes. Alternative GW-3 is the only alternative with comparable effectiveness; however, it does not address an area of highly contaminated bedrock ground water which is addressed in GW-4.

#### **9.4 USE OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES OR RESOURCE RECOVERY TECHNOLOGIES TO THE MAXIMUM EXTENT PRACTICABLE**

The selected remedy uses treatment and alternative technologies to the maximum extent practicable to achieve a permanent solution which is cost-effective. The treatment processes employed by this remedy will remove organic contamination from the soil up to an estimated 99% removal efficiency and immobilize the remaining contaminants both inorganic (metals) and organic with chemical and physical stabilizing processes. Removal and destruction of waste and the reduced mobility of contaminants both from the soil and ground water will provide a permanent solution to the maximum extent possible.

Although other alternatives would provide a protective remedy by reducing mobility of contaminants, no other remedy was as cost-effective in providing permanence through reduction in toxicity and volume of contaminants.

#### **9.5 PREFERENCE FOR TREATMENT AS PRINCIPAL ELEMENT**

As describe above, the selected remedy includes extensive treatment of both soil and ground water to reduce the toxicity, mobility and volume of contaminants at the site. The remedy includes the use of thermal extraction for organic contaminants and cement-based stabilization for inorganic contaminants in the Inactive Site soil. Chlorinated organic contaminants (TCE and 1,1,1-TCA) will be removed and contained from the Chemical Storage Tank area using in-situ soil vapor extraction. The ground water will be treated for VOCs, semi-volatiles and inorganic contaminants with a specialized process using UV photolysis and oxidation to treat NDMA.

The remedy that satisfies the preference for treatment as a principle element by requiring the treatment of each contaminant to the maximum extent practicable.

## 9.6 CONCLUSION

The selected remedy will meet the statutory requirements as specified in Section 121 of CERCLA by satisfying the threshold and balancing criteria for remedy selection as required by section 300.430(e) of the NCP. The State of Colorado has also accepted this remedy and has participated in its selection.

## 10.0 REFERENCES

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- Geraghty & Miller, Inc., 1987a. Results of Phase 1 Investigation, Martin Marietta Astronautics Group. Denver, Colorado. June 10, 1987.
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- Mackay, D.M., P.V. Roberts, and J.A. Cherry, 1985. Transport of Organic Contaminants in Ground Water. Environmental Science and Technology 19:364-392.
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**APPENDIX A**

**MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
RESPONSIVENESS SUMMARY**



## APPENDIX A

### Martin Marietta Astronautics Group Site Responsiveness Summary

The community relations responsiveness summary for the site is divided into two sections; 1. a brief description of the site and the selected remedy, and 2. a summary of the oral and written comments received during the public comment period concerning the Proposed Plan prepared by EPA.

#### 1. Overview

The Martin Marietta Astronautics Group (MMAG) site is located in Jefferson County near the mouth of Waterton Canyon on Highway 121 approximately 25 miles southwest of Denver. The site occupies approximately 5200 acres and has operated since the 1950s. Operations have included the manufacturing of rockets for the U.S. Air Force and research and development associated with aerospace equipment and fuels.

The facility is regulated under the Resource Conservation and Recovery Act (RCRA) as a treatment, storage and disposal facility. During the operating period prior to RCRA, the waste which could not be treated in the wastewater treatment plant on site was disposed of in five ponds located on site. The area is now called the Inactive Site Ponds and is a major source of ground water and soil contamination. There are several other sources of contamination on site which were investigated during the remedial investigation or area being investigated under closure requirements of the RCRA program.

The primary contaminants found at the site are volatile organic compounds (VOCs) including trichloroethene (TCE), 1,1,1-trichloroethane (TCA) and the degradation compounds from these chemicals; semi-volatile chemicals including N-nitrosodimethylamine (NDMA) which is a chemical associated with hydrazine fuels, and inorganic chemicals such as hexavalent chromium. The contamination is highly concentrated in the Inactive Site area soil and ground water. Another area with high levels of contamination in the ground water is the Manufacturing (M3) area. There are low levels of contamination found off site in the Denver Water Department (DWD) Kassler property.

There is a separate site located within the MMAG property which is federal facility and is on the National Priorities List. The site is approximately 464 acres and is owned by the U.S. Air

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Force. A separate program is in place to require the investigation of the site and select a remedy for the remediation of the site.

On June 28, 1990 EPA proposed the preferred alternative for remediating the site. The proposed remedy included Alternative S-5 for the Inactive Site and Chemical Storage Tank areas and Alternative GW-4 to address ground water. Both alternatives include extensive treatment of contaminated media.

Alternative S-5 requires that contaminated soils in the Inactive Site area be excavated and that waste be separated for treatment and disposal off site. The contaminated soil that remains on site will be treated by thermal extraction to remove organic chemicals and solidified to immobilize inorganic contaminants. The treated soil will be returned to the area of contamination and capped with a multi-layered cap. Residues from the treatment process will be transported off site for treatment and disposal.

Alternative GW-4 for the ground water is a site-wide remedy addressing contamination which originates from sources investigated during the remedial investigation and hazardous waste management units subject to RCRA regulations.

EPA solicited written and oral comment from the public during the comment period which began on June 28, 1990 and closed August 27, 1990. Comments were received during the public meeting, held July 26, 1990, from the National Toxics Campaign (NTC) representative. Written comments were submitted by MMAG.

## 2. Public Comments and Response

Comment: First of all, we feel that it is important that no additional air emissions be factored into a clean-up site, that we would be working as diligently as possible to reduce air emissions in the Denver metropolitan area. So that is something that is extremely important and needs to be addressed.

EPA Response: EPA agrees with the concern over introducing additional sources of air emissions as part of the remedy. After further consideration of the proposed alternative for ground water involving air stripping, EPA has decided to include emission controls as part of the final remedy for this process. This decision is based upon several factors including the EPA policy (OSWER Dir. 9355.0-28) applicable to areas of non-attainment for ambient air quality and the fact that MMAG is

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within an area of non-attainment, and the requirement in the NCP to reduce the toxicity, mobility or volume of contaminants through treatment. During the design phase, the specific type of control will be determined.

Comment: We also call for independent monitoring. We feel that this is extremely important as well, given the history of monitoring of different toxic contamination sites in Colorado.

EPA Response: As part of the regulatory responsibilities of EPA and the Colorado Department of Health (CDH) the authority to enter facilities and collect samples and conduct inspections is provided by law. However, neither EPA or CDH have the authority to require MMAG or any facility to allow a third party which does not represent the agencies to enter a facility to collect samples.

Specifically, pursuant to the Hazardous and Solid Waste Amendments (HSWA) Section 3007 and CERCLA Section 104(e), EPA is provided the authority to enter, inspect and collect samples from facilities treating, storing or disposing of hazardous waste or facility, vessel, location with hazardous substances. Part 3 of the Colorado Hazardous Waste Act (Section 25-15-301 (3)) authorizes CDH to enter and inspect hazardous waste facilities.

If any party desires samples from facility, then that party may contact the owner/operator of that facility and request permission to obtain samples directly from that facility.

Comment: MMAG believes that flexibility must be maintained throughout this cleanup process to allow the work to proceed in an effective and economical manner. This will allow the procedure to be updated as the knowledge of the site increases through time. A Record of Decision (ROD) that allows for this kind of continual feedback will result in an accelerated achievement of our goals with improved results.

EPA Response: EPA agrees that flexibility must be built into the ROD to allow for the development of the most cost-effective design of the remedy specified in the ROD. However, the ROD must specify the processes selected to remediate the contaminant conditions at the site. The ROD will retain flexibility accounting for the results of treatability studies which will be conducted during the design phase. Soil treatment standards are specified with provisions for a variance. In addition, the ROD acknowledges the potential difficulties with achieving the cleanup goals for ground water as specified in the ROD and includes provisions to evaluate the response action and treatment standards after a period of operation.

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**Comment:** The Endangerment Assessment (EA) that evaluates the risk to human health and the environment has used residential use scenario for the basis of evaluation. These requirements should be reconsidered in light of Jefferson County's recent request to further review zoning at the MMAG and the county desires that "visually sensitive areas (hogback, mountain front) be protected as zoned open space." These changes would reduce the health risk concerns, drinking water and showering with water from ground water source, and therefore affect the final cleanup requirements as specified in the Record of Decision.

**EPA Response:** The use of the residential scenario in the EA was done to evaluate the reasonable maximum exposure scenario for the site as required by EPA policy for conducting risk assessments. In doing so the EPA has a better understanding of the risk that may be posed to human health under conditions of maximum exposure and be able to communicate that information to the public. The fact that the zoning changes are being considered for the area does not change need to assess what EPA considers to be a potential reasonable maximum exposure scenario.

The final cleanup requirements specified in the ROD are based upon several requirements in the NCP and CERCLA. Specifically, with respect to ground water remediation, EPA is to consider restoring ground water to its beneficial use based upon previous uses and potential uses. The ground water from the site was used as a drinking water supply and the potential for that demand in the future exists. Furthermore, the EPA is to select remedies that attain permanent solutions through use of treatment whenever practicable and remedies must attain applicable or relevant and appropriate requirements (ARARs) or attain a waiver. Based upon these site conditions and requirements, the remedy selected is the most appropriate for the site and reconsideration of the standards set forth in the ROD based upon zoning which is subject to change would be inappropriate.

**Comment:** The soils alternatives evaluated in the presentation of the Proposed Plan did not consider two of the alternatives set forth in the Feasibility Study (FS), limited action and in-situ stabilization. The limited action alternative relies on isolating the property to prevent exposure while the in-situ stabilization depends on adding materials to the soil that decreases the transport rate of contaminants while they decompose naturally. These alternatives do not appear to completely meet the requirements for this cleanup but could compliment the other technologies. Again, they add to the flexibility that we believe is needed in this ROD.

**EPA Response:** The limited action alternative and the in-situ stabilization alternative are not supported in the FS as beneficial over the comparable alternatives, no action and ex-situ stabilization, respectively. The limited action alternative does not provide any significant increase in protection to

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human health or the environment when compared to the no action alternative. Most of the components (e.g., restrictions) associated with the limited action are inherent with (or will be incorporated into) the selected alternative during the design phase, thus addressing the Martin Marietta comment that limited action could compliment the other technologies. The FS demonstrated that the in-situ stabilization process is inferior to the ex-situ stabilization process with respect to effectiveness and implementability. The costs were near equivalent. As such, the EPA does not believe that in-situ stabilization warrants any further consideration. It should be noted that the FS is the mechanism used to reduce the range of alternatives to a manageable number of the most feasible alternatives.

Comment: The request that the ROD remain flexible should be especially exercised in the soil vapor extraction technology, suggested in all alternatives, for cleanup of soil contamination at the chemical storage tanks. The site compatibility for this removal method must be evaluated before specifying the technique. We suggest that a pilot test of the technology be incorporated.

EPA Response: EPA agrees that a pilot study should be conducted during the design phase to determine the feasibility of in-situ soil vapor extraction. EPA, however, believes that in-situ soil vapor extraction will work in this particular application and will specify in-situ soil vapor extraction in the ROD. Should the process fail during the design phase, another process would be identified.

Comment: The on-site treatment and excavation called for in alternatives S-3 through S-5 in the proposed plan are based on handling the cover material, waste sludge, contaminated alluvium and contaminated backfill. The contaminated backfill, which was not included in the proposed plan, should be combined with the contaminated alluvium and termed contaminated soil to be compatible with the FS report.

EPA Response: While it may not have been clearly stated in the Proposed Plan, references made to contaminated backfill and/or contaminated soil were intended to refer to both contaminated backfill and alluvium that corresponds to a volume of 24,400 cubic yards. This will be clearly stated in the ROD and the term "contaminated soil" will be used when referring to contaminated backfill and alluvium.

Comment: Based on the current information available, the region where Pond #2 was located appears to be uncontaminated. If additional data gathered during the design phase verifies this fact, it seems unnecessary to remediate that area. This also seems like a reason to maintain flexibility in

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the discussion on the area that needs to be covered by the cap. The extent and nature of the cap should be called out in the design report which will reflect the results of the additional study needed.

**EPA Response:** During the design phase, additional field sampling will be required to more accurately determine the extent of contamination. From this information, the cap will be designed to cover the contaminated area. A RCRA cap, however, will be specified in the ROD to the extent shown in the FS which covers all five ponds. The extent of the cap may increase, decrease, or remain the same depending on the results of the field sampling program conducted during the design phase.

**Comment:** Alternative S-5 should state clearly that the collected volatile residue from the thermal extraction process and the excavated waste must be treated and disposed of off-site while the remainder of the material can be handled on-site. The ROD should clarify the target remedial action level and target treatment level with the flexibility to accommodate the results of the design and pilot results.

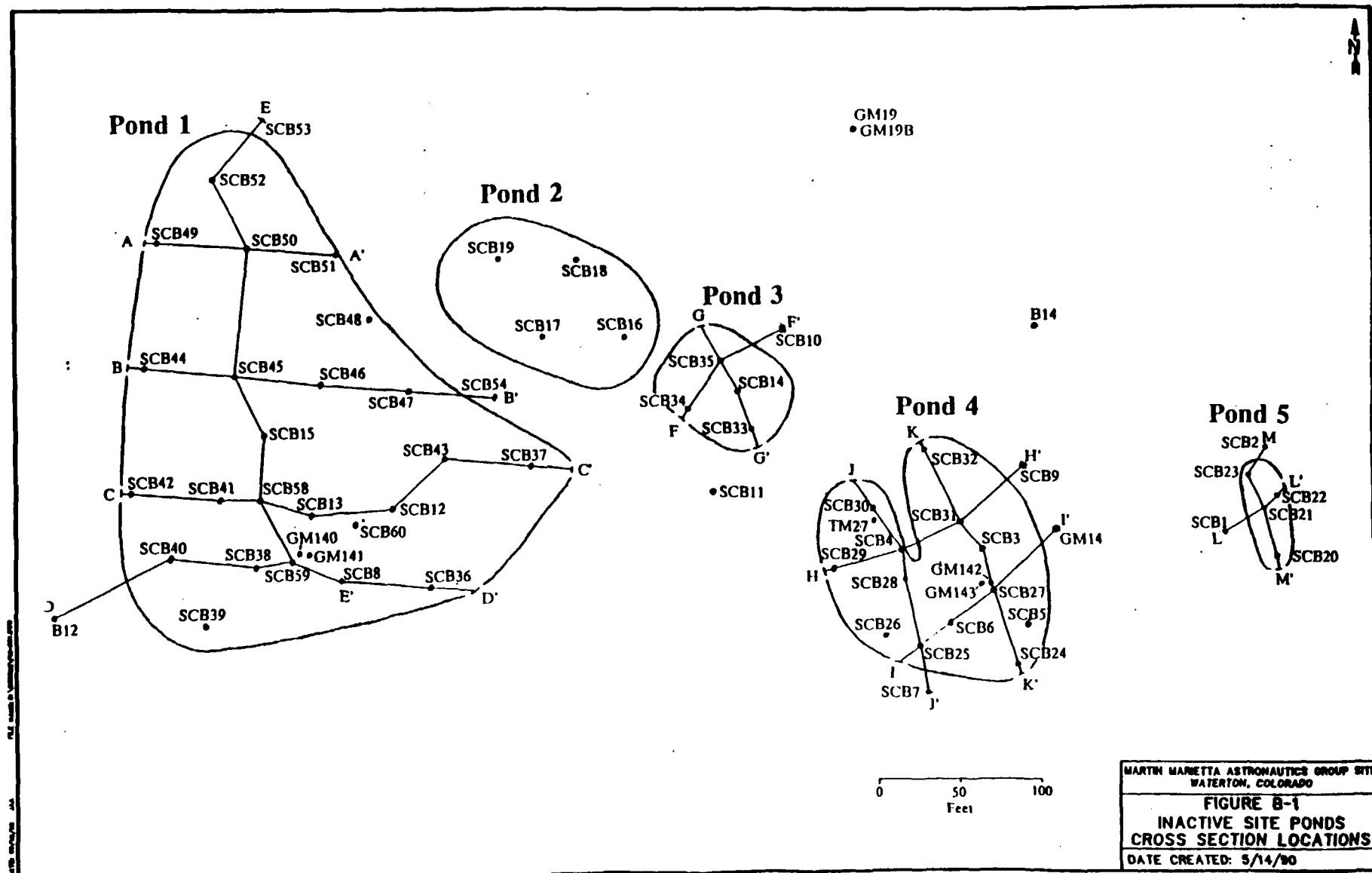
**EPA Response:** The ROD will be written to clearly state that the waste and thermal extraction residues will be treated and disposed of off-site and the remainder of the material can be treated and disposed of on-site. Target remedial action levels and treatment levels will be presented in the ROD and clarified as necessary to account for the analytical method detection limits and attainable treatment technology levels.

**Comment:** The ground water treatment system described in alternative GW-4 should leave the nature and order of the process step open so an economical design can be developed to best protect the environment. This may leave the operations in the current MMAG wastewater treatment plant available for final polishing.

**EPA Response:** EPA agrees with this comment, however, the process order presented in the Proposed Plan was taken from the FS and will be used in the ROD for the purpose of presenting the selected remedy. The design will dictate the order of the unit processes.

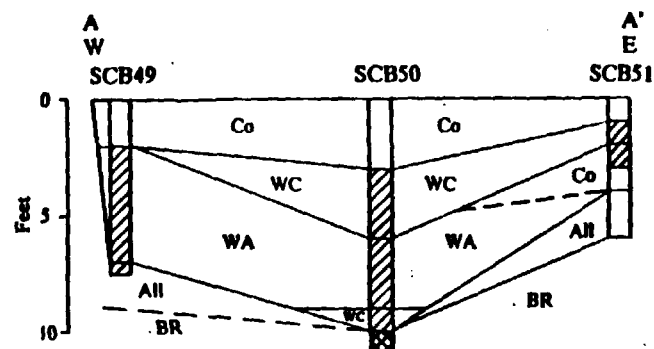
September 19, 1990

**APPENDIX B**  
**MARTIN MARIETTA ASTRONAUTICS GROUP SITE**  
**INACTIVE SITE PONDS**  
**CROSS SECTIONS**





# Pond 1



SCB49	2ft-8ft	SCB50	3ft-11ft	SCB51	1ft-3ft
Cr	595 mg/kg	Cr	34 mg/kg	Cr	34 mg/kg
TCE	ND ug/kg	TCE	530 ug/kg	TCE	ND ug/kg
TCA	ND ug/kg	TCA	1710 ug/kg	TCA	57 ug/kg
Cis-DCE	ND ug/kg	Cis-DCE	ND ug/kg	Cis-DCE	ND ug/kg

## Cross-Section Key

- Co = Cover Material
- All = Alluvium
- WA = Asphalt Rich Waste
- WC = Clay Rich Waste
- BR = Bed Rock
- [Hatched Box] = Interval Sampled
- [Cross-hatched Box] = Infiltrating Sludge

Horizontal Scale = 1:300

Vertical Scale = 1:60

## Contaminant Concentration Key

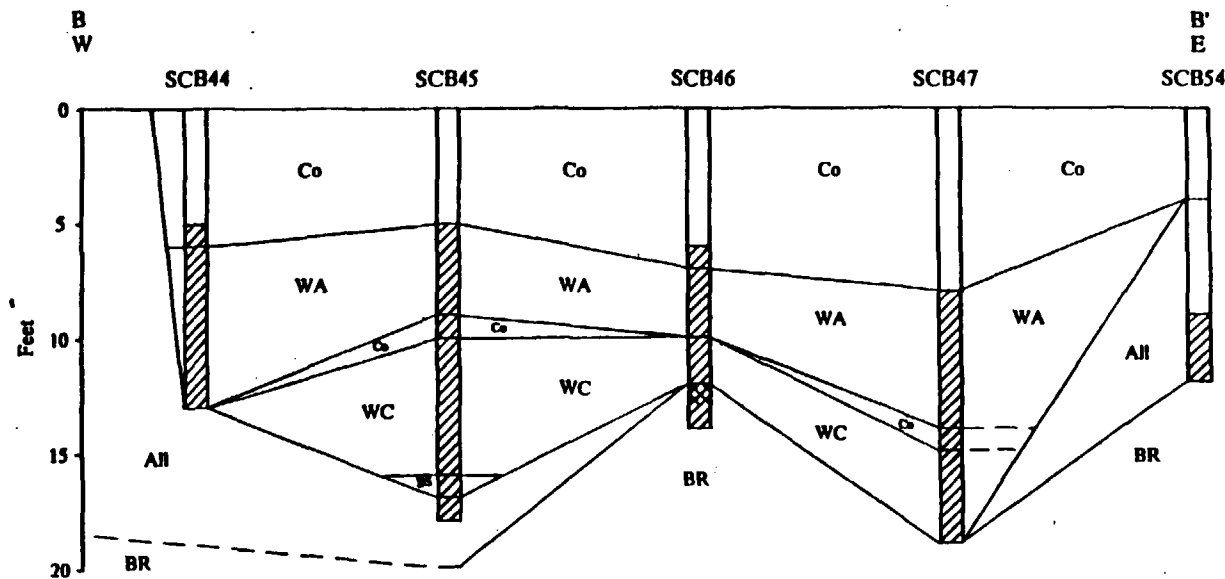
- SCB49 = Soil Boring Identification
- 2ft-8ft = Interval Sampled
- Cr = Total Chromium
- TCE = Trichloroethene
- TCA = 1,1,1-Trichloroethane
- Cis-DCE = Cis-1,2-Dichloroethene
- ND = Not Detected

MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
WATERTON, COLORADO

FIGURE B-2  
POND 1  
CROSS SECTION A-A'

DATE CREATED: 5/14/90

# Pond 1



**Cross-Section Key**  
 CO = Cover Material  
 All = Alluvium  
 WA = Asphalt Rich Waste  
 WC = Clay Rich Waste  
 BS = Black Sludge  
 BR = Bed Rock  
 [Hatched] = Interval Sampled  
 [Cross-hatched] = Infiltrating Sludge

Horizontal Scale = 1:300  
 Vertical Scale = 1:60

SCB44 5ft-13ft  
 Cr 20 mg/kg  
 TCE ND ug/kg  
 TCA 351 ug/kg  
 Cis-DCE 647 ug/kg

SCB45 5ft-18ft  
 Cr 95 mg/kg  
 TCE 646 ug/kg  
 TCA ND ug/kg  
 Cis-DCE 57 ug/kg

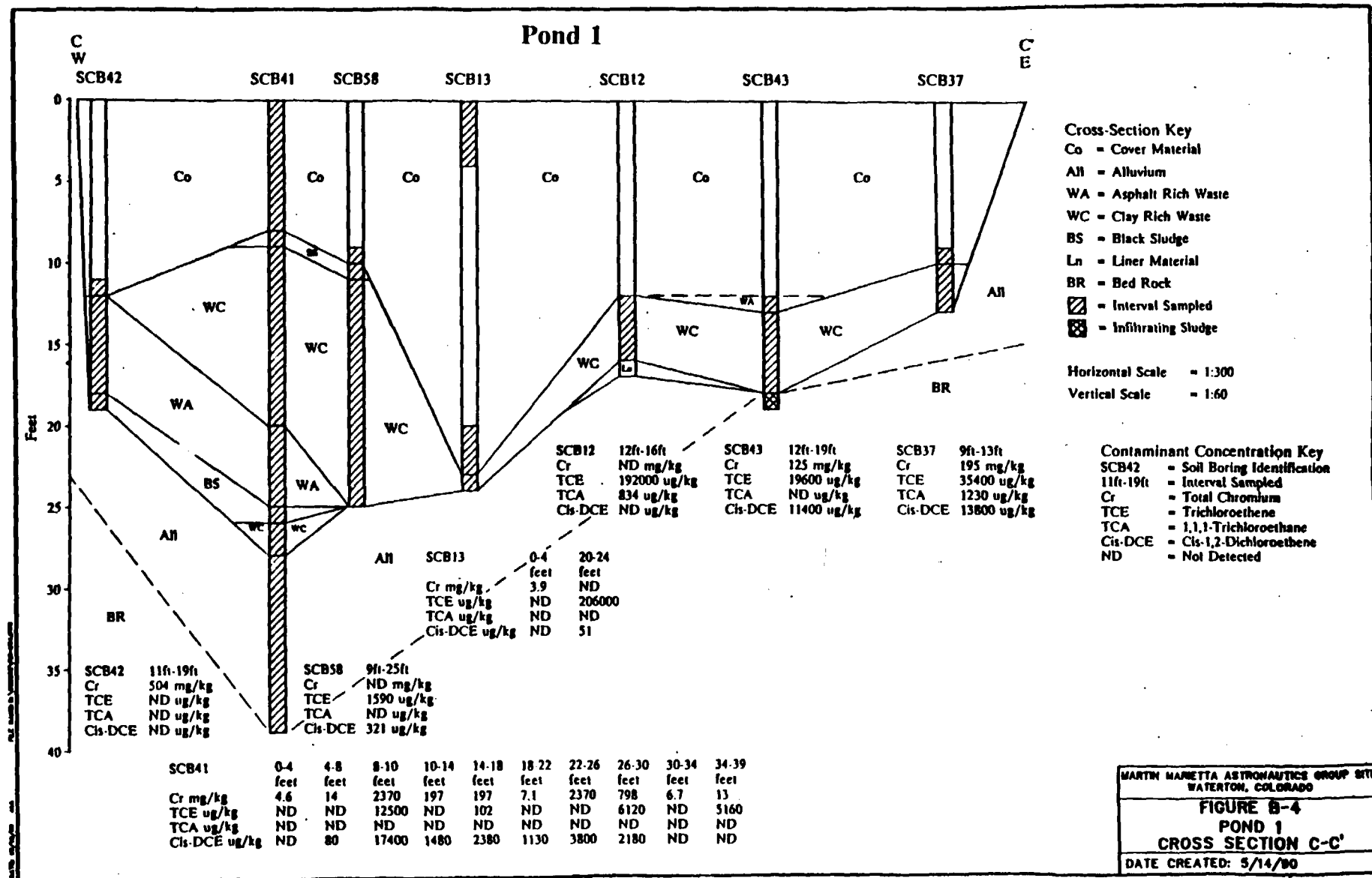
SCB46 6ft-14ft  
 Cr 5 mg/kg  
 TCE ND ug/kg  
 TCA ND ug/kg  
 Cis-DCE ND ug/kg

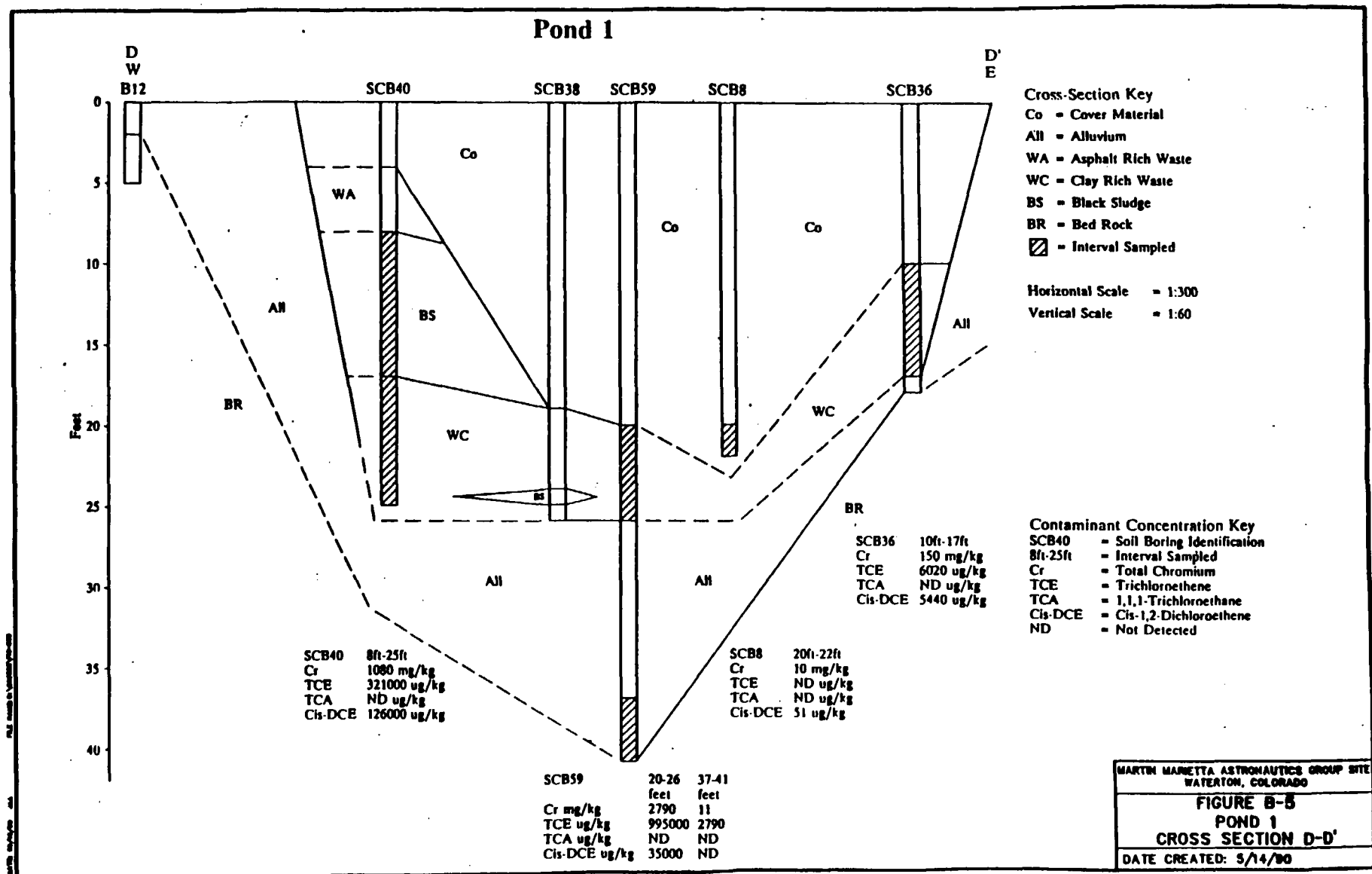
SCB47 10ft-19ft  
 Cr 72 mg/kg  
 TCE ND ug/kg  
 TCA ND ug/kg  
 Cis-DCE 92 ug/kg

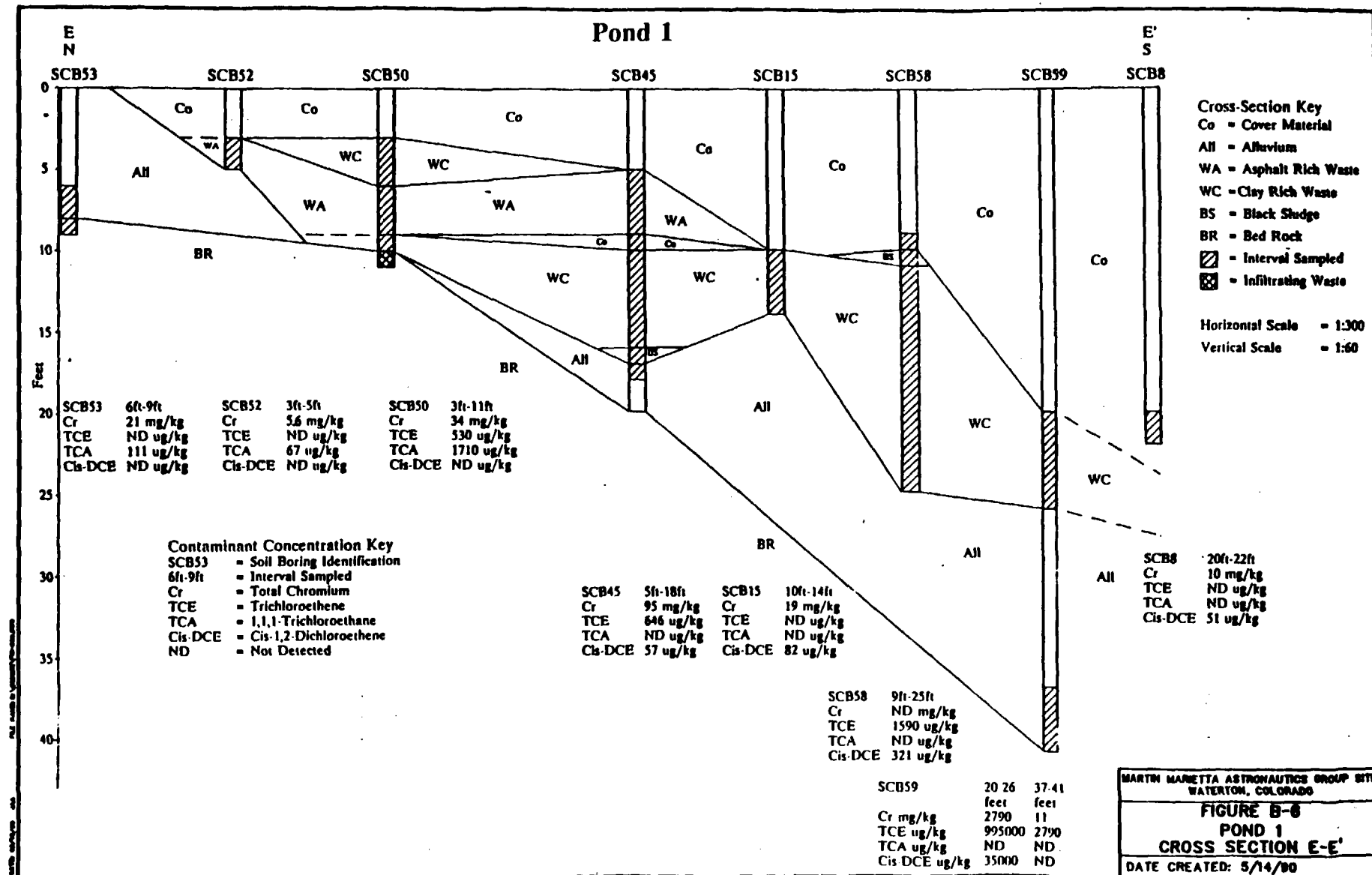
SCB54 9ft-12ft  
 Cr 12 mg/kg  
 TCE ND ug/kg  
 TCA ND ug/kg  
 Cis-DCE ND ug/kg

**Contaminant Concentration Key**  
 SCB44 = Soil Boring Identification  
 5ft-13ft = Interval Sampled  
 Cr = Total Chromium  
 TCE = Trichloroethene  
 TCA = 1,1,1-Trichloroethane  
 Cis-DCE = Cis-1,2-Dichloroethene  
 ND = Not Detected

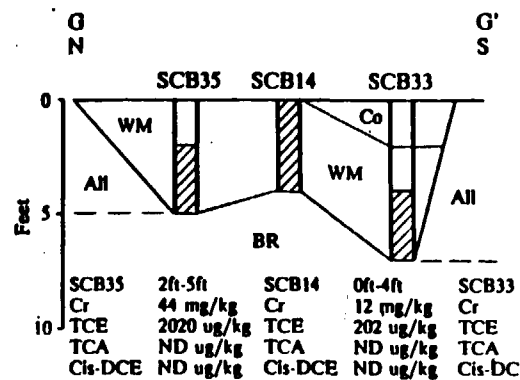
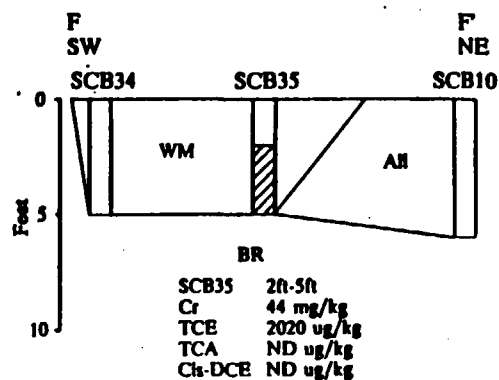
MARTIN MARIETTA ASTRONAUTICS GROUP SITE  
 WATERTON, COLORADO  
**FIGURE B-3**  
**POND 1**  
**CROSS SECTION B-B'**  
 DATE CREATED: 5/14/00







# Pond 3



## Cross-Section Key

- Co = Cover Material
- All = Alluvium
- WM = Waste Mix
- BR = Bed Rock
- ▨ = Interval Sampled

Horizontal Scale = 1:300

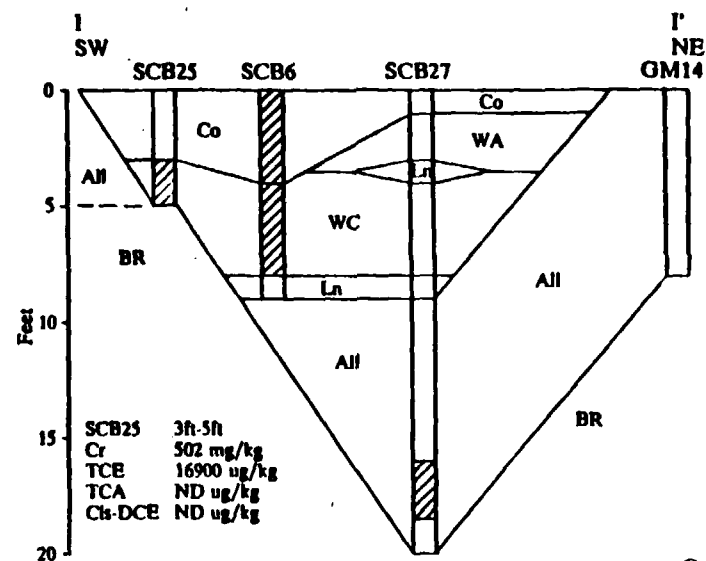
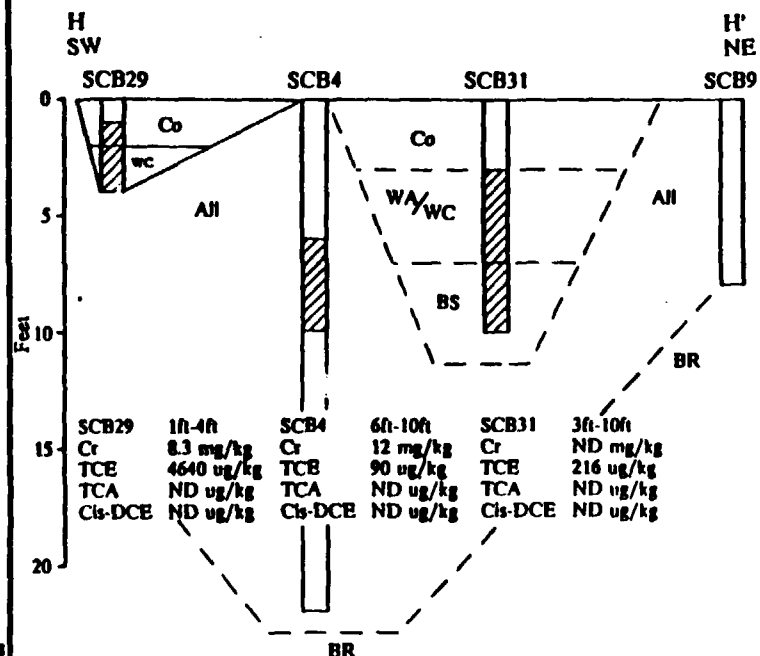
Vertical Scale = 1:60

- Contaminant Concentration Key**
- SCB35 = Soil Boring Identification
  - 2ft-5ft = Interval Sampled
  - Cr = Total Chromium
  - TCE = Trichloroethene
  - TCA = 1,1,1-Trichloroethane
  - Cis-DCE = Cis-1,2-Dichloroethene
  - ND = Not Detected

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**FIGURE B-7**  
**POND 3**  
**CROSS SECTION F-F' & G-G'**  
DATE CREATED: 5/14/90

# Pond 4



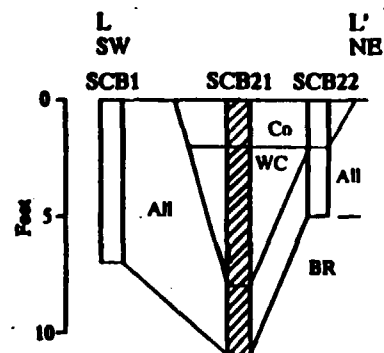
**Cross-Section Key**  
 Co = Cover Material  
 All = Alluvium  
 WA = Asphalt Rich Waste  
 WC = Clay Rich Waste  
 BS = Black Sludge  
 Ln = Liner Material  
 BR = Bed Rock  
 [Hatched Box] = Interval Sampled

Horizontal Scale = 1:300  
 Vertical Scale = 1:60

**Contaminant Concentration Key**  
 SCB29 = Soil Boring Identification  
 1ft-4ft = Interval Sampled  
 Cr = Total Chromium  
 TCE = Trichloroethene  
 TCA = 1,1,1-Trichloroethane  
 Cis-DCE = Cis-1,2-Dichloroethene  
 ND = Not Detected

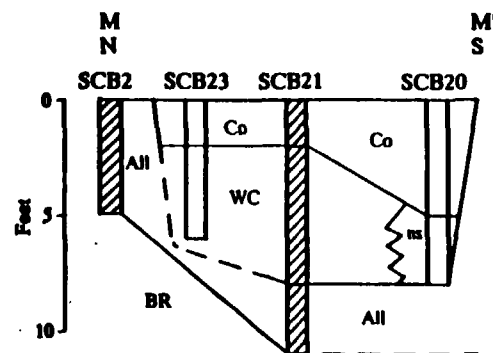
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**FIGURE B-8**  
**POND 4**  
**CROSS SECTION H-H' & I-I'**  
 DATE CREATED: 5/14/80

## Pond 5



SCB21	0-2 feet	2-4 feet	4-6 feet	6-8 feet	8-10 feet	10-11 feet
Cr mg/kg	54	267	856	28900	38	38
TCE ug/kg	706	2590	1100000	4700000	260000	330000
TCA ug/kg	ND	ND	ND	163000	ND	130000
Cis-DCE ug/kg	ND	161	ND	ND	ND	ND

**Contaminant Concentration Key**  
 SCB2 = Soil Boring Identification  
 0ft-5ft = Interval Sampled  
 Cr = Total Chromium  
 TCE = Trichloroethene  
 TCA = 1,1,1-Trichloroethane  
 Cis-DCE = Cis-1,2-Dichloroethene  
 ND = Not Detected



SCB2	0ft-5ft
Cr	98 mg/kg
TCE	36600 ug/kg
TCA	3690 ug/kg
Cis-DCE	ND ug/kg

SCB21	0-2 feet	2-4 feet	4-6 feet	6-8 feet	8-10 feet	10-11 feet
Cr mg/kg	54	267	856	28900	38	38
TCE ug/kg	706	2590	1100000	4700000	260000	330000
TCA ug/kg	ND	ND	ND	163000	ND	130000
Cis-DCE ug/kg	ND	161	ND	ND	ND	ND

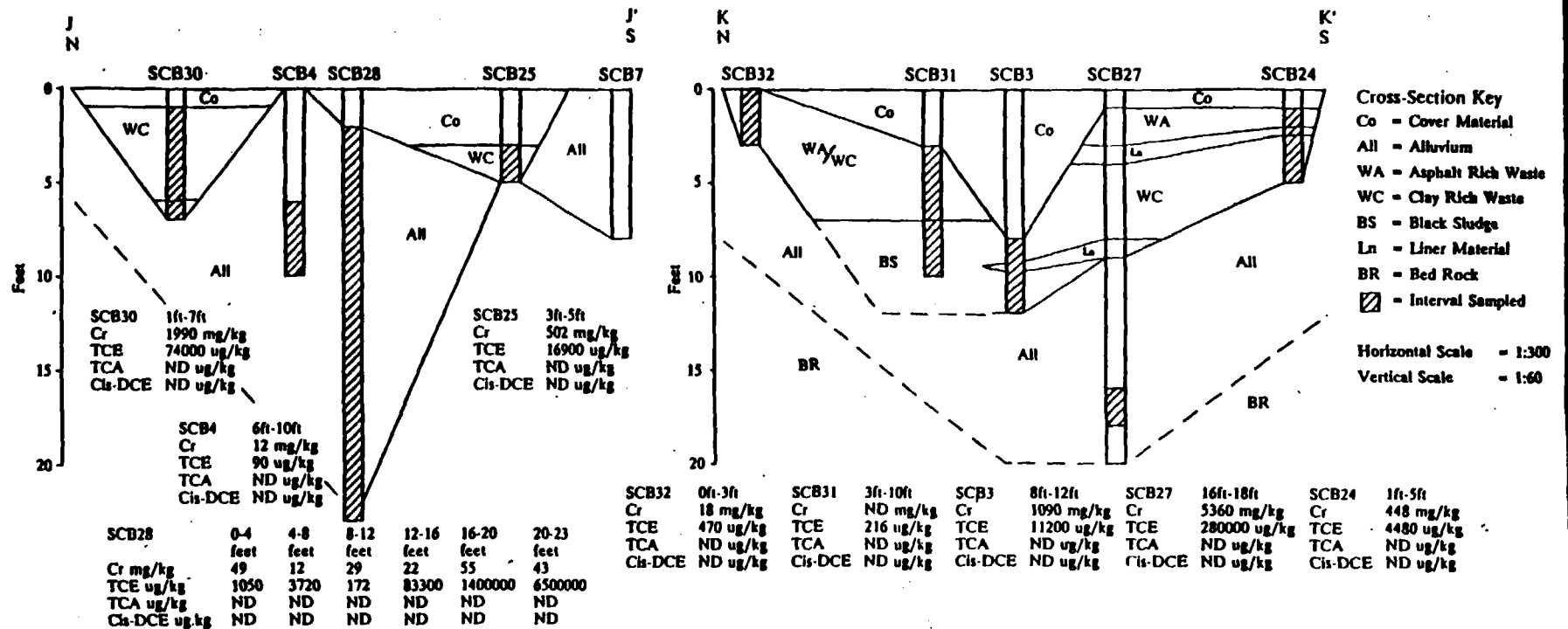
**Cross-Section Key**  
 Co = Cover Material  
 All = Alluvium  
 WC = Clay Rich Waste  
 BS = Black Sludge  
 BR = Bed Rock  
 [Hatched Box] = Interval Sampled

Horizontal Scale = 1:300  
 Vertical Scale = 1:60

MARTIN MARETTA ASTRONAUTICS GROUP SITE  
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**FIGURE B-10**  
**POND 5**  
**CROSS SECTION L-L' & M-M'**  
 DATE CREATED: 5/14/90



# Pond 4



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